Soil Science Research Report - 1988

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AN ECONOMIC AND RESOURCE ANALYSIS OF DEEP TILLAGE TO REDUCE SOIL COMPACTION FOR CROP PRODUCTION

Alice J. Jones, Steve Swanson, Joe Skopp, Ed Penas, Doug Duey, Leonard Bashford, Charles Shapiro, and Richard Ferguson.

Objectives:

(1) To measure the effect of deep tillage on soil properties associated with soil compaction;

(2) To measure the effect of deep tillage on crop yields and root growth;

(3) To evaluate the economic return to crop production on deep tilled soils.

Procedures: Sixteen farmer fields representing 10 soil types were included in the study. Two tillage treatments were imposed on each field in the fall of 1986: 1) surface tillage only; 2) surface tillage plus deep tillage. Each treatment was replicated six times in a randomized complete block design with each experimental unit being about 40 * 100 feet in area.

During the 1987 growing season soybeans (variety Hobbit) were planted. In 1988 corn was planted at 6 sites, soybeans at 9 sites, and sorghum at 1 site. All planting was done by the cooperator.

Soil samples were taken to a depth of 2 feet in the spring and fall of the 1987 growing season and to a depth of 1.5 feet in the 1988 growing season. These samples were evaluated for bulk density, soil water content, and air filled porosity. Penetrometer resistance was monitored concurrently.

Results: Management practices used by the cooperator in 1988 are presented in Table 1. Tillage intensity ranged from 0 to 4 operations. Weed growth was controlled chemically at all sites and in conjuction with row crop cultivation at 9 of the 16 locations. Among sites, 16 different herbicides were applied. Starter fertilizer was applied with the seed at 6 of the sites. Tractors used in field operations included 2WD, 4WD, and front-wheel assist models ranging in horsepower from 65 to 235. Fields were planted between April 15 and June 8. Harvest dates reflect the period from September 7 to October 10 when research samples were collected.

Results from 1988 generally indicated little differential growth as a result of subsoiling (Table 2). Plant height measured early or late in the growing season for the nonsubsoiled or subsoiled treatments was not substantially different, however, there was a consistent trend for the subsoiled treatment to be taller than the nonsubsoiled. This difference across all locations was 0.4 and 1.6 cm for the corn and 0.7 and 0.6 cm for the soybeans during the early and late monitoring periods, respectively. Plant color for corn and soybeans ranged from 5GY 5/6 to 5GY 4/4 using the Munsell color system and tended to portray darker values and chromas later in the season. Phenology indicated the stage of development at the time of observation. Soybeans and corn in the vegetative (V) or reproductive (R) stage exhibited the same degree of advancement (i.e. 3,4,5 etc.) except for 3 sites on the early season monitoring. For these exceptions the subsoiled plots had progressed one leaf node stage (soybeans) or one collared leaf stage (corn) ahead of the nonsubsoiled plots.

No significant differences in plant population were observed except at 1 site. Soybean yields were similar for subsoiled and nonsubsoiled treatments at all locations with subsoiled treatment yields being slightly greater at 5 of the 6 sites. Corn yields were more varied between subsoiled and nonsubsoiled treatments with the subsoiled treatments having greater yields at 3 sites and nonsubsoiled at 2 sites. These differences, in general were not significant for most soybean sites, but were significant at 4 of the 6 corn sites. Yield increases due to subsoiling were greatest at Gauchat's and Jones for soybeans and corn respectively.

The economic analysis for 1987 and 1988 was based on cooperator inputs and tillage operations. It was anticipated that a cooperator who would choose to deep till would use a 7- or 9-shank subsoiler with a rental tractor having 275- or 325-horsepower. Net returns to the cooperator ranged from -$77 to +$139 (Table 3), and from -$144 to +$142 (Table 4), for the 1987 and 1988 growing seasons respectively. Net return was calculated as the total crop price per acre minus production costs including cash and fixed costs, management, overhead, and labor. Subsoiling contributed to a higher net return for only Gauchat and Schmidt in 1987, and for Gauchat, Jones, Nelson, Ottjenbruns, and Schure in 1988 as compared to the nonsubsoiled plots. Additional yield and economic data will allow us to more clearly define both the soil and yield response to deep tillage over a period of years.

Cooperator	Fertilizer	Tractor	Tillage	Herbicide		Herbicide Application	Plant Date	Harvest Date
Ottjenbruns	None	160 4WD	Landsmen	Eradicane	5.3 pt	Incorporated	5/2	9/7
		140 2WD	RCC[1]	Atrazine	2.4 pts	Incorporated		
				2-4,D	1 pt	Broadcast-Sprayer		
Jones	Anhydrous 80 lbs/A	108 2WD	RCC	Bladex	2 qt	Broadcast-Sprayer	5/5	9/12
	46-0-0 80 lbs/A	55 2WD		Atrazine	1 qt	Broadcast-Sprayer		
Schutte	Anhydrous 100 lbs/A	98 2WD	Disk	Lasso	2 qt	Planter-Banded	5/18	9/21
	18-46-0 100 lbs/A	98 2WD	FC[2]	Bladex	1.7 qt	Planter-Banded		
		125 2WD	RCC					
Lefler	Anhydrous 210 lbs/A	180 4WD	FC[2]	Lasso	2 qt	Split-Shot	4/26	9/19
(Center Pivot)	18-46-0 50 lbs/A	140 2WD	RCC[1]	Atrazine	1.2 qt	Split-Shot		
				Counter	8 lbs	Broadcast		
Schmidt	None	170 FWA	FC	Treflan	1.25 pt	Broadcast-Incorporated	5/20	10/7
		180 2WD		Scepter	.67 pts	Broadcast-Incorporated		
Clausen	None	180 FWA	Disk	Classic	.75 oz	Sprayer	5/15	9/23
			Noble Blade					
			FC					
			RCC					
Gauchat	None	100 2WD	No-tillage	Dual	2 pt	Broadcast-Sprayer	5/16	9/27
		145 4WD		Preview	8 oz	Broadcast-Sprayer		
				2-4,D	.5 pt	Broadcast-Sprayer		
Harlan	Anhydrous 120 lbs/A	235 4WD	RCC[1]	Genate	5 pt	Pivot	4/15	9/9
(Center Pivot)		165 2WD						
Glock	None	130 2WD	Disk	Lasso	2 qt	Broadcast-Sprayer	5/27	10/5
(Gravity)		75 2WD	Hiller	Command	1 pt	Broadcast-Sprayer		
			Rotary Hoe					
			RCC					
Adelman	None	325 4WD	Subsoiler	Prowl	2 pt	Incorporate	5/20	9/25
		140 2WD	FC	Scepter	.67 pt	Incorporate		
Schure	Anhydrous 120 lbs/A	210 2WD	FC	Extrazine	2.75 pt	Broadcast-Floater	5/5	9/6
		70 2WD	RCC					
Laflin	Anhydrous 100 lbs/A	115 2WD	No-tillage	Extrazine	1.25 qt	Broadcast-Sprayer	5/23	N/A
				2-4,D	1 pt	Broadcast-Sprayer		
Newsham	None	190 FWA	FC	Lasso	2 qt	Split-Shot	6/8	10/10
		165 2WD	RCC	Sencor	.5 lbs	Split-Shot		
Nelson	None	125 2WD	No-tillage	Salute	2.25 pt	Sprayer	5/10	10/3
		65 2WD	No-tillage					

[1] RCC = Row Crop Cultivator   [2] FC = Field Cultivator

Table 2. Growth characteristics for deep tillage research.

County	Cooperator	Treatment	Plant Height T_1	Plant Height T_2	Plant Color T_1	Plant Color T_2	Phenology T_1	Phenology T_2	Plant Population (Plants/Acre)	Yield Bu/Acre	% Change
					5GY						
Butler	Glock	None	37.8	103.5	5/4	5/4	V5	R7	78408	48	+2
		Subsoiled	38.3	103.9	5/4	5/4	V5	R7	75504	49	
Cuming	Schutte	None	79.5	222.8	5/4	5/4	V9	R4	15682	77	+0
		Subsoiled	79.3	223.2	5/4	5/4	V10	R4	15131	77	
Fillmore	Lefler	None	70.9	229.7	4/4	4/4	V9	R4	28575	203	-1
		Subsoiled	71.3	231.4	4/4	4/4	V9	R4	28227	202	
Johnson	Laflin	None	30.0	97.8	5/4	5/4	3.0	6.0	57714	N/A	
		Subsoiled	32.3	97.2	5/4	5/4	3.0	6.0	60525	N/A	
Knox	Clausen	None	14.8	65.4	4/4	4/4	V2	R7	118300	25	+0
		Subsoiled	14.5	64.3	4/4	4/4	V2	R7	117199	25	
Lancaster	Harlan	None	75.2	217.6	5/4	4/4	V8	R4	45012	110	-7
		Subsoiled	76.9	217.6	5/4	4/4	V9	R4	45738	103	
	Ottjenbruns	None	70.5	175.4	4/4	4/4	V7	R4	15333	46	+24
		Subsoiled	70.3	176.8	4/4	4/4	V7	R4	16030	57	
Madison	Adelman	None	27.7	88.7	4/4	4/4	V3.5	R7	106722	33	-6
		Subsoiled	28.8	90.8	4/4	4/4	V3.5	R7	101640	31	
	Schmidt	None	37.0	85.8	4/4	4/4	V3.0	R6	161717	53	+2
		Subsoiled	36.9	88.1	4/4	4/4	V3.0	R6	161717	54	
Nemaha	Gauchat	None	19.3	76.0	4/4	4/4	V3.5	R7	347235	40	+13
		Subsoiled	19.4	75.5	4/4	4/4	V4.0	R7	336034	45	
Platte	Schure	None	89.4	135.9	4/4	4/4	V11	R4	17057	63	+16
		Subsoiled	86.6	143.2	4/4	4/4	V11	R4	17607	73	
Richardson	Jones	None	87.3	141.1	5/4	5/6	V10	R4	14636	41	+44
		Subsoiled	90.8	140.1	5/4	5/6	V10	R4	14984	59	
Saunders	Newsham	None	34.7	93.6	4/4	4/4	V3.5	R6	148975	41	+5
		Subsoiled	36.2	92.9	4/4	4/4	V3.5	R6	145490	43	
Washington	Nelson	None	34.7	70.8	4/4	4/4	V3.0	R7	106607	32	+9
		Subsoiled	35.6	72.0	4/4	4/4	V3.0	R7	107295	35	

Table 3. 1987 Crop Budget Results

Cooperator	Subsoil	Cash Costs	Labor	Fixed Costs	Overhd/ Mgt.	Net Returns
Adelman	Y	39.70	5.46	92.76	12.51	42.62
	N	36.21	4.74	86.97	12.70	59.03
Clausen	Y	92.03	8.07	75.39	16.06	48.54
	N	84.07	7.12	72.60	15.60	29.60
Gauchat	Y	55.63	5.53	100.19	14.39	37.11
	N	47.23	4.58	97.17	12.26	20.25
Glock	Y	74.43	10.31	171.18	21.29	46.64
(Irr-Gravity)	N	66.34	9.36	168.31	20.30	46.99
Harlan	Y	80.65	8.41	150.00	13.60	-77.21
(Irr-Pivot)	N	72.56	7.46	147.29	13.77	-55.18
Jones	Y	74.10	7.24	111.64	20.48	93.99
	N	65.91	6.29	108.89	20.37	111.48
Laflin	Y	70.43	9.79	109.65	19.78	88.45
	N	62.43	8.84	106.90	19.62	104.71
Lefler	Y	115.67	8.45	151.89	25.01	51.53
(Irr-Pivot)	N	107.57	7.50	149.09	24.49	61.70
Nelson	Y	70.90	10.48	162.82	20.97	55.53
	N	62.38	9.53	160.11	21.21	78.42
Newsham	Y	53.67	6.37	91.43	16.57	86.60
	N	45.75	5.42	88.67	16.36	101.75
Ottjenbruns	Y	60.68	6.81	102.95	11.55	-25.49
	N	52.62	5.42	99.86	11.15	-13.30
Schure	Y	54.73	7.45	105.72	15.79	55.56
	N	46.56	6.50	102.86	14.84	58.59
Schutte	Y	41.15	9.94	92.27	13.61	54.78
	N	33.11	8.99	89.50	13.27	67.99
Schmidt	Y	58.05	8.47	87.84	20.00	139.13
	N	49.71	7.52	84.94	18.72	136.66

Table 4. 1988 Crop Budget Results

Cooperator	Subsoil	Cash Costs	Labor	Fixed Costs	Overhd/ Mgt	Net Returns
Adelman	Y	43.40	4.85	90.59	11.47	20.19
	N	40.48	4.12	85.75	11.92	39.22
Clausen	Y	88.26	9.10	80.38	11.91	- 52.15
	N	80.93	8.23	77.88	11.55	- 41.08
Gauchat	Y	65.28	14.79	106.91	16.76	43.76
	N	57.55	13.92	103.97	14.88	29.68
Glock (Irr-Gravity)	Y	81.63	8.84	175.21	18.78	- 14.95
	N	74.24	7.97	172.66	18.11	- 8.98
Harlan (Irr-Pivot)	Y	106.68	8.20	152.44	15.63	-102.71
	N	99.75	7.33	150.12	15.99	- 80.69
Jones	Y	87.45	10.57	122.42	10.27	-127.46
	N	78.90	9.70	119.25	8.05	-144.14
Laflin	Y	54.57	8.55	105.30	11.73	- 36.15
	N	47.25	7.68	102.79	11.36	- 25.08
Lefler (Irr-Pivot)	Y	178.18	8.09	162.15	29.11	- 24.03
	N	170.79	7.22	159.69	28.84	- 11.29
Nelson	Y	52.02	6.74	124.67	13.10	- 4.06
	N	44.86	5.87	122.03	11.84	- 8.62
Newsham	Y	50.15	6.20	98.24	15.41	66.50
	N	42.68	5.33	95.37	14.43	67.68
Ottjenbruns	Y	57.79	8.10	125.67	8.59	-100.41
	N	49.78	7.24	122.73	7.09	-106.33
Schure	Y	79.56	6.02	106.60	11.28	- 75.70
	N	71.61	5.15	103.69	9.88	- 64.04
Schutte	Y	79.53	11.60	107.06	11.68	- 75.11
	N	72.20	10.73	104.55	11.31	- 64.04
Schmidt	Y	48.14	5.21	88.14	18.61	136.91
	N	44.05	4.34	82.58	18.10	142.42

EFFECT OF PHOSPHORUS RATE, METHOD OF APPLICATION AND TILLAGE ON SOYBEAN YIELD IN NEBRASKA

T. A. Essman, C. A. Shapiro,
D. H. Sander, and R. B. Ferguson

OBJECTIVE: To determine the effect of different methods of P application on soybean yield and P content as influenced by tillage and available soil P.

PROCEDURE: Experiments were conducted at four locations in Nebraska. There were two locations in Southeastern NE (Nemaha and southern Lancaster Counties), and one location each in Northeastern and South-Central NE in Cedar and Webster Counties respectively. Two tillage systems (disk and no-till were studied at the Nemaha and Cedar County sites. All sites were dryland except the Cedar County location, which was center pivot irrigated. The experimental design used at the two locations with tillage was a split-plot 3 x 4 factorial, with tillage as the whole plot and rate x method combinations as the split plot The two locations without the tillage variable were set up as a randomized complete block design. The phosphorus placement methods were preplant broadcast (incorporated in disk tillage) preplant knifing at 15-inch spacings, 4-6 inches deep, and row application (1 inch below and 3 inches beside the seed). Phosphorus rates were 0, 18, 37, 55, and 74 lbs P_2O_5/acre respectively. Phosphorus was ammonium polyphosphate (10-34-0; N-P_2O_5-K). All treatments received equal amounts of nitrogen by mixing urea-ammonium nitrate solution (28-0-0) with the ammonium polyphosphate. In the no-till system soybeans were planted directly into the standing corn/sorghum residue. The disk system involved disking prior to planting and disked again for fertilizer incorporation. Leaf, whole plant and grain P concentrations were determined. Leaf samples were taken at R4 stage, and whole plant samples at the R10 stage (See Table 1).

RESULTS AND DISCUSSION: At the Cedar County site where B-K#1 P tests were 4.7 ppm, yields increased with applied P. Plant uptake of P was significantly increased with applied P. Grain P concentrations were not different. Disk tillage produced higher yields than no till (32.2 vs. 30.0 bu/ac respectively). (See Tables 2-3).

At the Nemaha County site near Auburn, NE (B-K#1=6.4 ppm P), grain yield was significantly higher when P was knifed or row applied compared to broadcasting, especially at the higher P rates (Table 4). The best rate x method combination for yield was when the highest rate of P was knifed. It was significantly higher than every other combination. Plant P uptake was slightly higher for row and knifing compared to broadcast P, and increased slightly as rate increased. Tillage effects on yield showed disking to be significantly better than the no-till, (18.3 vs. 14.8 bu/ac, respectively). Grain P concentration showed a positive linear to P rate (See Tables 4-5).

The Lancaster County location near Firth, NE had a B-K#1 P test of 6.8 ppm. A significant rate x method interaction indicated that yield increased as P rate increased when P was either row or knife applied, but broadcast P did not affect yield at any rate. Plant P uptake showed a significant increase with knife and row applications over the broadcast method, with the knife having a slightly higher P concentration than row. Grain P concentrations showed a significant positive linear response to rate of P application. Tillage variables were not tested at this dryland site (See Tables 6-7).

The Webster County location near Bladen, NE had a B-K#1 P test of 7.0 ppm. Yield increased linearly as P rate increased, with the knife application increasing grain yield more than either row or broadcast P. Plant P uptake also showed a positive linear response to P rate (See Tables 8-9).

Check plots testing the affect of nitrogen at all four locations did not show significant yield differences. Therefore, at these sites, addition of nitrogen alone did not increase yields significantly. Check plots testing the disturbance of the knife treatments showed no significant effect on yield at the three dryland sites, but the Cedar County site showed a significant decrease in yield due to knifing.

Table 1. Significant information for all locations, 1988.

Heading	Nemaha	Cedar	Lancaster	Webster
Cropping History	Corn 1987	Corn 1987	Corn 1987	Corn 1987
Plot Area	460′ x 150′	500′ x 180′	220′ x 160′	205′ x 150′
Plot Size	10′ x 40′	10′ x 40′	10′ x 40′	10′ x 40′
Tillage	Disk & N.T.	Disk & N.T.	Disk till	Disk till
Planted	May 27	June 2	May 26	June 3
Variety	Century	Century	Century	Century
Herbicide	Pre:5/20/88 2,4-D ester; 2.5 qt Lasso MT; Post:7/8/88 1 qt Basagran 1 qt Dash 1 pt Poast 4 oz Butyrac;	Pre:6/3/88 2.5 qt Lasso MT; .5 pt Lorox L; .5 qt Roundup; 12 ox X-77; Post:6/21/88 1 pt Poast; 1 qt Dash;	Pre:5/19/88 .33# Sencor+ 2.5 pt Sonalan	Pre:5/22/88 "Squadron" (2# Prow + .33# Scepter)
Insecticide	None	None	None	None
Harvest	Oct 12	Oct 10	Oct 12	Oct 14

Table 2. Effect of Phosphorus Rate and Placement (rate x method interaction) on soybean grain yield, stover P and grain P. 1988. Cedar County.*

P Rate	Row			Knife			Broadcast		
	Yield	Stover P	Grain P	Yield	Stover P	Grain P	Yield	Stover P	Grain P
lb P_2O_5/ac	bu/ac	----- % -----		bu/ac	----- % -----		bu/ac	----- % -----	
18	16.6	.064	.52	18.0	.065	.49	17.1	.052	.48
37	16.5	.064	.50	16.9	.060	.55	14.7	.050	.46
55	18.3	.048	.53	17.4	.054	.55	14.8	.065	.50
74	18.4	.075	.54	21.2	.057	.53	15.6	.061	.51

Method of Application

*Crofton silty clay loam; 6-11% slope (eroded).

Table 3. Mean values of rate, placement, and tillage systems. 1988. Cedar County.

P Rate	Grain Yield	Stover P	Grain P
lbs P_2O5/ac	bu/ac	------------- %	-------------
0	13.9	.061	.48
18	17.2	.060	.49
37	16.1	.060	.50
55	16.8	.056	.53
74	18.1	.065	.53
No-till	14.8	.055	.52
Disk	18.3	.063	.50
Row	17.2	.064	.52
Knife	18.4	.059	.53
Broadcast	15.6	.057	.49

Table 4. Effect of phosphorus Rate, Placement (rate x method interaction) on soybean grain yield, stover P, and grain P. 1988. Nemaha County.*

P Rate	Method of P Application								
	Row			Knife			Broadcast		
	Yield	Stover P	Grain P	Yield	Stover P	Grain P	Yield	Stover P	Grain P
lb P_2O_5/ac	bu/ac	----- %	-----	bu/ac	----- %	-----	bu/ac	----- %	-----
18	33.2	.064	.52	18.0	.065	.49	17.1	.052	.48
37	16.5	.064	.50	16.9	.060	.55	14.7	.050	.46
55	18.3	.048	.53	17.4	.054	.55	14.8	.065	.50
74	18.4	.075	.54	21.2	.057	.53	15.6	.061	.51

*Marshall silty clay loam; 5-11% slope (eroded).

Table 5. Effect of P rate, tillage and method of P application (main effect means) on soybean grain yield, stover P, and grain P. Nemaha County. 1988.

P Rate	Grain Yield	Stover P	Grain P
lbs P_2O_5/ac	bu/ac	-------------- %	--------------
0	13.9	.061	.48
18	17.2	.060	.49
37	16.1	.060	.50
55	16.8	.056	.53
74	18.1	.065	.53
No-till	14.8	.055	.52
Disk	18.3	.063	.50
Row	17.2	.064	.52
Knife	18.2	.059	.53
Broadcast	15.6	.057	.49

Table 6. Effect of phosphorus rate and placement on soybean grain yield, stover P, and grain P. 1988. Lancaster County.*

P Rate	Method of Application								
	Row			Knife			Broadcast		
	Yield	Stover P	Grain P	Yield	Stover P	Grain P	Yield	Stover P	Grain P
lb P_2O_5/ac	bu/ac	----- % -----		bu/ac	----- % -----		bu/ac	----- % -----	
18	20.1	.087	.44	20.4	.089	.48	20.0	.065	.49
37	21.1	.077	.48	20.5	.078	.45	21.1	.090	.53
55	21.6	.094	.49	21.5	.097	.62	20.7	.075	.40
74	22.2	.106	.53	21.5	.107	.60	19.8	.070	.54

*Kennebec silt loam; 0-2% slope.

Table 7. Mean values of rate, placement, and tillage systems. 1988. Lancaster County.

P Rate	Grain Yield	Stover P	Grain P
lbs P_2O_5/ac	bu/ac	----- % -----	
0	19.9	.077	.51
18	20.2	.080	.47
37	20.9	.082	.49
55	21.3	.089	.50
74	21.2	.094	.56
Row	21.3	.091	.49
Knife	21.0	.093	.54
Broadcast	20.7	.075	.49

Table 8. Effect of phosphorus rate and placement on soybean grain yield, stover P, and grain P. 1988. Webster County.*

P Rate	Method of Application								
	Row			Knife			Broadcast		
	Yield	Stover P	Grain P	Yield	Stover P	Grain P	Yield	Stover P	Grain P
lb P_2O_5/ac	bu/ac	----- % -----		bu/ac	----- % -----		bu/ac	------ % ----	
18	10.1	.016	.56	10.6	.019	.62	8.6	.010	.59
37	9.6	.026	.55	11.6	.015	.64	9.8	.025	.65
55	10.4	.022	.65	12.2	.015	.62	9.7	.025	.71
74	10.3	.037	.78	11.3	.020	.77	12.6	.021	.63

*Holdrege silty clay loam; 7-10% slope (severely eroded).

Table 9. Mean values of rate, placement and tillage systems. 1988. Webster County.

P Rate	Grain Yield	Stover P	Grain P
lbs P_2O_5/ac	bu/ac	-------------%	---------------
0	8.4	.020	.63
18	9.7	.015	.59
37	10.3	.022	.62
55	10.8	.021	.66
74	10.3	.026	.72
Row	10.1	.020	.63
Knife	11.4	.017	.66
Broadcast	10.2	.020	.64

Increasing Nitrogen use efficiency by dryland sorghum under conventional disk and no-tillage systems.

M.V. Marake, D.T. Walters and D.H. Sander.

Objectives:

1) To evaluate the effects of no-tillage and conventional disk systems on dryland sorghum production and fertilizer N use efficiency.
2) To determine the effect of different N sources, timing of N application and placement of N on dryland sorghum production under different tillage systems.

Procedures:

The experiment was conducted at the Agricultural Research and Development Center at Mead, Nebraska. The soils at the site were the Sharpsburg silty clay loam (Typic Argiudoll) and Butler silty clay loam (Abruptic Argiudoll). The experiment was replicated four times as a split plot in a randomized complete block design. Blocking was carefully arranged on the basis of soil type. Main plots consisted of 2 tillage treatments (conventional spring disk (D) and no-tillage (NT) (30m x 30m)) and a factorial combination of N rate, N source/placement and N application time as the subplot (9.2m x 4.6m). The subplot treatments consisted of:

A) N source and placement

  1) Urea ammonium nitrate (28% N UAN) solution surface dribbled between sorghum rows (UD)
  2) UAN knifed between sorghum rows (UK)
  3) Anhydrous Ammonia (AA)

B) N timing

  1) Preplant (PP)
  2) Sidedress (SD)

C) N rate (kg N /ha): 0, 40, 80 and 120.

The control treatments (0 N rate) were knifed with no fertilizer applied at both times of application for UK and AA N sources. Sorghum (Pioneer 8333-72 day RM) was seeded on June 6th 1988 at a rate of 4.5 kg/ha in a 0.75m row spacing. Weeds were chemically controlled with periodic hand hoeing of weed escapes. Nitrogen was applied preplant on May 19th, 1988 and sidedressed on July 14th, 1988 when the sorghum was at the 8-leaf stage (growing point differentiation).

Three rows were combine harvested for grain yield and a single row was harvested for determination of stover yield and N uptake. Total nitrogen was determined on all grain and stover by the Kjeldahl method. This experiment was a repeat of the 1987 experiment on the same plot areas with no treatment modification. Extremely dry surface soil conditions at planting resulted in some erratic germination. Grain yields were calculated on the basis of harvested area (row length). Analysis of covariance revealed a significant quadratic relationship between harvested row length and grain yield and yield data were adjusted accordingly. An analysis of variance for treatment main effects and interactions and single degree of freedom contrasts are presented in Tables 1 and 2, respectively.

Results:

Despite a very dry growing season, sorghum grain yield averaged 5.41 Mg/ha (98 bu/A) and ranged between 3.56 and 6.61 Mg/ha (65-120 bu/A) depending on treatment. Total rainfall for the months of April, May, June, July, August and September was 3.63, 8.33, 2.59, 9.08, 1.82, and 12.19 cm respectively (Figure 1). Crop response to nitrogen rates was influenced by both tillage and timing of N application. Nitrogen rate requirement for maximum yield was 40 kg/ha greater for no-till with a tendency for higher grain yields in the NT system at higher rates of N application. When N was applied at sidedress time, the N requirement for maximum yield was 40 kg/ha greater than preplant N requirement (Figure 2). The effect of time on the sorghum response to N rate was confounded with N form/placement and tillage. Anhydrous ammonia was a superior N source for sidedress application but inferior to UD or UK for preplant in NT. Surface dribbled UAN at PP time under disk tillage resulted in a significant reduction in grain yield (Figure 3). Dry conditions at planting (June 6th) extended for 23 days after planting, and it is probable that appreciable volatile N losses or positional unavailability of N due to dry surface soil conditions may have occurred.

Grain N uptake was similarly influenced by the interaction of time and rate of N application. Sidedress N application at rates above 40 kg N/ha resulted in significantly greater grain N content than preplant N applications . Both PP and SD application of UD in disked plots resulted in lower N uptake than when AA was the N source. However PP application of UD in NT did not result in reduced grain N uptake (Table 3). It is hypothesized that sufficient surface soil moisture was conserved under NT management to sustain an active root system near the surface to counteract the effects of dry weather on N availability.

Over all treatments, stover dry matter production was consistently greater under NT than disk. There was a quadratic relationship between N rate and stover dry matter production with maximum stover yield occurring with an application rate of 80 kg N/ha at preplant. Nitrogen application at sidedress time under the disk system did not result in an increase in vegetative growth (Figure 4). Sidedressed N was applied at the time when the growing point changes from vegetative (leaf producing) stage to the reproductive (head producing) stage. At this time, total leaf number has been determined and nutrient uptake is at a maximum. Both stover yield and N uptake were influenced by time and form of N applied. Preplant UD was less effective than sidedress UD when compared to UK or AA form/placements (Table 4). Moreover, stover yield and N uptake showed a significant quadratic response to preplant N regardless of tillage system. Stover yield was influenced linearly by N rate at preplant but not at sidedress. Interestingly, grain yield response was increased at both times of N application (Fig. 3). This suggests that the sorghum plant utilized sidedress applied N for grain N components rather than stover.

Summary:

Dryland sorghum grain yield and N use efficiency were influenced by tillage, N form and placement and time of N application in 1988. An extremely dry growing season in 1988 did not adversely affect sorghum grain production. Although more N was required to reach maximum grain production under no tillage, improved soil water conservation under NT as compared to disk resulted in greater grain production at N rates exceeding 80 kg N/ha. Sidedress N application increased grain yield and N uptake preferentially over stover components under disk tillage.

A prolonged dry period following planting resulted in a significant yield loss under conventional disk tillage when N was surface applied as UAN. This was not observed under no tillage. Conservation of surface soil moisture and the maintenance of an active root system near the soil surface under no-tillage are thought to contribute to these results. Anhydrous ammonia was a superior N source to UAN.

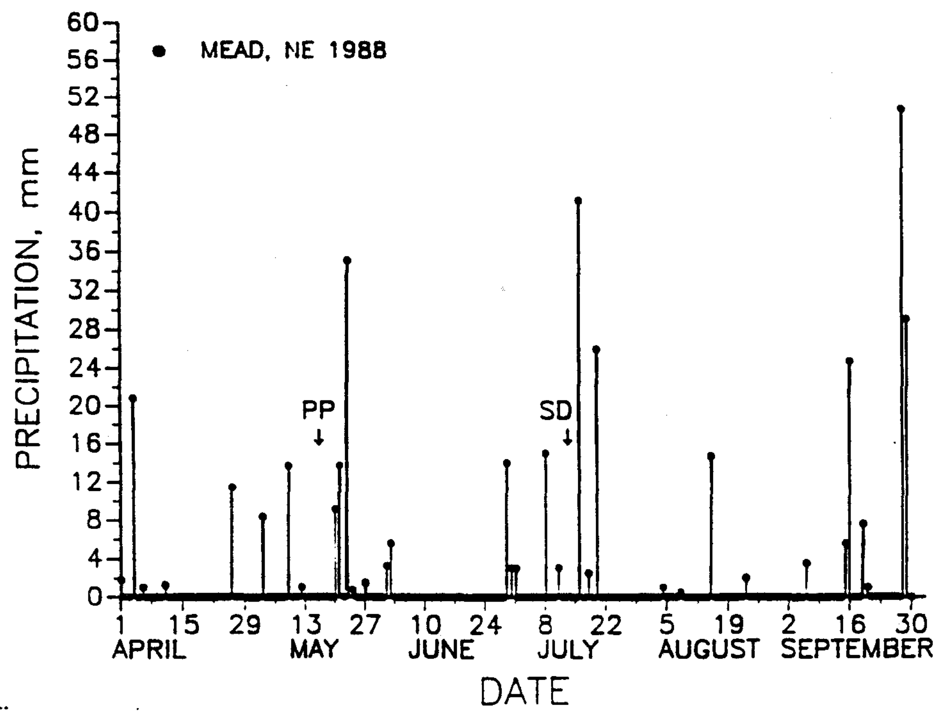


Figure 1. Daily precipitation record for Mean, Nebraska, April-Sept. 1988.
PP = preplant SD = sidedress

Table I. Analysis of covariance table for dry matter yield and nitrogen content of dryland grain sorghum. Mead, 1988.

Source of Variation	DF	GY	SY	NG	NSt
		PR>F			
Till	1	NS	.002	NS	.02
Time	1	NS	NS	NS	.04
Till*Time	1	NS	NS	NS	NS
NFP	2	NS	NS	NS	NS
Till*NFP	2	NS	NS	NS	NS
Time*NFP	2	NS	NS	NS	NS
Till*Time*NFP	2	NS	NS	NS	NS
Rate	3	.001	.001	.001	.001
Till*Rate	3	NS	NS	NS	NS
Time*Rate	3	.03	NS	.06	NS
NFP*Rate	6	NS	NS	NS	NS
Till*Time*Rate	3	NS	.05	NS	NS
Till*NFP*Rate	6	NS	NS	NS	NS
Time*NFP*Rate	6	NS	NS	NS	NS
Till*Time*NFP*Rate	6	NS	NS	NS	NS

Table 2. Single degree of freedom contrasts for dryland sorghum dry matter yield and nitrogen content. Mead, 1988.

Contrasts	DF	GY	SY	NG	NSt
		PR>F			
Till*(AAvsUK)	1	NS	NS	NS	NS
Till*(UKvsUD)	1	NS	NS	NS	NS
Till*Nrate	1	NS	NS	NS	NS
Till*NrateL	1	.05	NS	NS	NS
Till*NrateQ	1	NS	NS	NS	NS
Till*Time*(AAvsUK)	1	.08	NS	.05	.10
Till*Time*(UKvsUD)	1	NS	NS	NS	NS
Till*Time*NrateL	1	NS	NS	NS	NS
Till*Time*NrateQ	1	NS	.06	NS	NS
Till*(AAvsUK)*Nrate	1	NS	NS	NS	NS
Till*(AAvsUK)*NrateL	1	NS	NS	NS	NS
Till*(AAvsUK)*NrateQ	1	NS	NS	NS	NS
Till*(UKvsUD)*Nrate	1	NS	NS	NS	NS
Till*(UKvsUD)*NrateL	1	NS	NS	NS	NS
Till*(UKvsUD)*NrateQ	1	NS	NS	NS	NS
Time*(AAvsUK)	1	NS	NS	NS	NS
Time*(UKvsUD)	1	NS	NS	NS	NS
Time*NrateL	1	.01	.09	.02	NS
Time*NrateQ	1	NS	.09	NS	NS
Time*(AAvsUK)*Nrate	1	NS	NS	NS	NS
Time*(AAvsUK)*NrateL	1	NS	NS	NS	NS
Time*(AAvsUK)*NrateQ	1	NS	NS	NS	NS
Time*(UKvsUD)*Nrate	1	NS	NS	NS	NS
Time*(UKvsUD)*NrateL	1	NS	.08	NS	.06
Time*(UKvsUD)*NrateQ	1	NS	NS	NS	NS
(AAvsUK)	1	NS	NS	.07	NS
(UKvsUD)	1	NS	NS	NS	NS
(AAVsUK)*Nrate	1	NS	NS	NS	NS
(AAvsUK)*NrateL	1	NS	NS	.06	NS
(AAvsUK)*NrateQ	1	NS	NS	NS	NS
(UKvsUD)*Nrate	1	NS	NS	NS	NS
(UKvsUD)*NrateL	1	NS	NS	NS	NS
(UKvsUD)*NrateQ	1	NS	NS	NS	NS
NrateL	1	.001	NS	.001	.001
NrateQ	1	.001	.001	.001	.001

GY=Grain Yield, SY=Stover Yield,
NG=Grain N (kg/ha), NSt=Stover N (kg/ha)
NS=not significant at probability level > 0.1

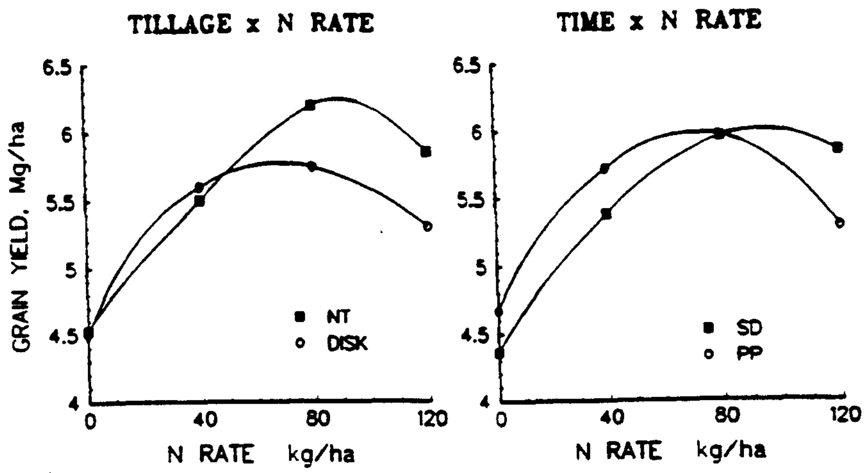


Figure 2. Tillage x N rate and time x N rate effects on dryland sorghum grain yield. Mead 1988.

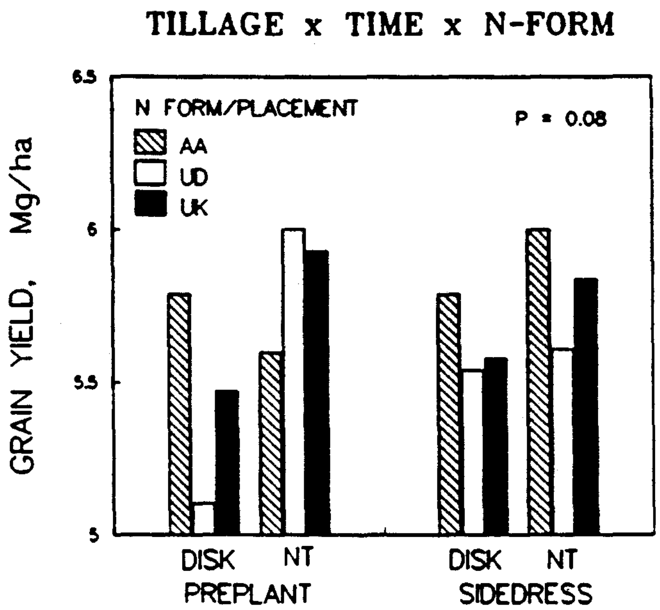


Figure 3. Tillage x N form/placement x N application time effects on dryland sorghum grain yield. Mead 1988.

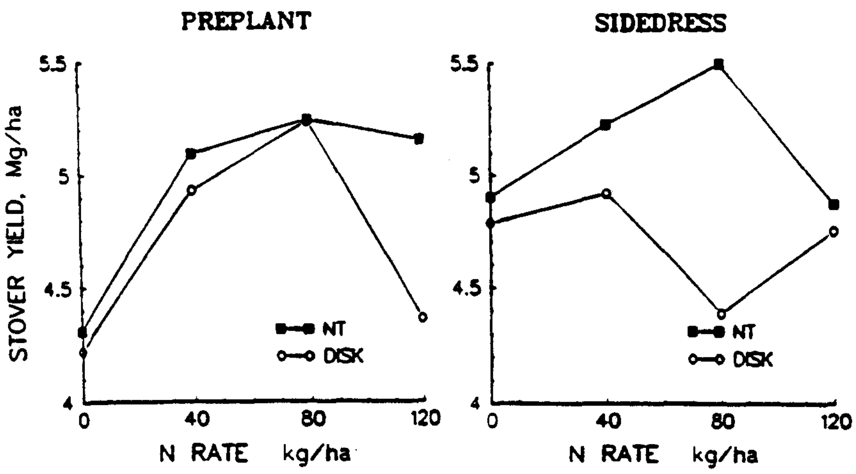


Figure 4. Tillage x time x N rate effects on dryland sorghum stover yield. Mead 1988.

Table 3. Till x Time x NFP interaction means for grain N uptake and stover N uptake. Mead, 1988.

	DISK		NO-TILL	
NFP	PP	SD	PP	SD
	Grain N uptake Kg/Ha			
AA	122	127	120	141
UD	110	119	129	117
UK	117	122	124	123
	Stover N uptake Kg/Ha			
AA	106	102	109	125
UD	96	107	112	114
UK	105	102	99	103

Table 4. Time x NFP x N rate interaction means for stover yield and N uptake. Mead, 1988.

	PREPLANT			SIDEDRESS		
RATE	AA	UD	UK	AA	UD	UK
KG/Ha	Stover yield Mg/ha					
0	4.42	3.95	4.43	4.99	4.87	4.68
40	4.96	4.69	5.39	5.17	5.46	4.58
80	5.82	5.03	4.86	4.87	4.98	4.99
120	4.62	4.93	4.73	4.75	4.95	4.73
	Stover N uptake Kg/ha					
0	87	81	84	99	97	94
40	104	95	108	118	112	92
80	121	107	101	111	106	109
120	98	109	98	110	112	106

Nitrogen Placement Evaluation for Winter Wheat in Three Fallow Tillage Systems

G. E. Varvel, J. L. Havlin, and T. A. Peterson

OBJECTIVE:

To determine if N placement below the zone of organic matter or surface residue accumulation would reduce N immobilization and increase yields in a winter wheat-fallow cropping system in western Nebraska.

PROCEDURE:

Two sets of plots for a tillage experiment on a winter wheat-fallow rotation were initiated at the Nebraska Agricultural Experiment Station High Plains Agricultural Laboratory, 11 km north of Sidney, NE in 1969. Fallow tillage systems were no-till (chemical weed control), stubble mulch (subsurface tillage), and conventional (moldboard plow). Whole plots (8.6- by 61.2-m) were split to accommodate N rates of 0 and 45 kg ha^{-1}, broadcast as NH_4NO_3 in April of the crop year. Whole-plot treatments were arranged in a randomized complete block design with four replications. Two sets of plots (located within about 15 m of each other) were used because the crop-fallow rotation required one plot to be fallow while the other plot was being cropped. Nitrogen split-plots were 4.3 m wide by 61.2 m long. Soil type was Alliance silt loam (fine-silty, mixed, mesic Aridic Argiustolls) for both sets of plots.

To compare fertilizer placement, method subplots were randomly allocated within each of the 45 kg N ha^{-1} split-plots in each tillage system for broadcast and subsurface applications of ^{15}N-depleted (99.99% ^{14}N) NH_4NO_3. The only other rate in the study was a 0 kg N ha^{-1} rate, which could not be tagged. Winter wheat cv. "Centurk78", was seeded in 30 cm rows at a rate of 50 kg seed ha^{-1}. Depleted fertilizer applications of 45 kg N ha^{-1} were made on 18 Sept. 1984, 24 Sept. 1985, and 18 Sept. 1986, shortly after seeding.

Above-ground whole plant samples were harvested at physiological maturity (20 June 1985, 26 June 1986, and 24 June 1987) from a one m^2 area within both N isotope treated plots and from 0 N subplots. Harvested samples were separated into stems (plus leaves) and heads and oven dried at 85°C to a constant weight; dry matter production (straw plus heads) was then calculated. Grain harvest at maturity was taken on 14 July in all three years from a 2.8 m^2 area. Grain samples were oven dried at 85°C to a constant weight and grain yields were calculated. Subsamples were ground and analyzed for total N and N-isotope ratio from both sets of harvest samples.

RESULTS AND DISCUSSION:

Results showed that both tillage and fertilizer N application significantly affected plant growth, N concentration, and N uptake for all sampling dates (Tables 1 and 2). An exception was N concentration in straw at physiological maturity (Table 1). Nitrogen response was consistent across tillage systems (no tillage system by N rate interaction). The plow system, in all cases, produced the highest yield, N concentration, and N uptake while no-till produced the lowest at both N rates in all three years.

Dry matter yields (straw and heads) and grain yields were also significantly affected by fallow method when averaged over placement methods on both sampling dates during the three years of the study (Table 3). Yields were greatest in the plow and least in the no-till system with stubble mulch intermediate (Table 3). Nitrogen concentrations in the grain and straw were similarly affected, with the highest concentration in the plow and the lowest in the no-till system. Significantly different N uptake values were obtained because the tillage system with highest yields (plow) also had highest N concentrations (Table 3).

The above results showing differences between tillage systems were not expected because of established differences in water storage between tillage systems (no-till>stubble mulch> plow) shown by other researchers. Although not measured, water storage patterns for this study were assumed to be similar to those reported earlier, which should result in greater yields for the no-till system if water becomes limiting. In these studies, water was severely limiting during the 1984 growing season only, but visual observation of early spring and summer growth patterns indicated more rapid development in the plow system as compared to the other two systems during all three years, probably because of warmer soil temperatures (1 to 2°C) in that system. Soil temperature reductions due to surface residues in the no-till and stubble mulch systems apparently negates the importance of the additional soil water stored during fallow, resulting in reduced early crop development, crop growth, and final yields in this environment.

In these systems, N placement did not affect grain or straw yield, N concentration, or N uptake during the three years of the study (Table 4). Labeled N measurements showed similar results, with no differences between tillage systems (Table 3) or N placement methods (Table 4). Concentration of labeled N was surprisingly constant between tillage systems and N placement methods, indicating that similar amounts of applied fertilizer were available for plant uptake from all tillage/placement combinations (tillage by placement effects were nonsignificant).

Labeled N uptake was significantly affected by tillage system (Table 3), but not by fertilizer placement during the study (Table 4). Similarly, the quantity of isotopic N derived from fertilizer was significantly affected by tillage system (Table 3) but not by N placement method (Table 4). Tillage system effects were significant due to differences in dry matter yields in both cases.

CONCLUSIONS:

Overall, results from the study were consistent and very little year to year variation was obtained. In all three years, grain and straw yield, N concentration, N uptake, labeled N uptake, and percent N derived from fertilizer were lowest for no-till and highest for plow. The consistency of results and lack of differences between placement methods in any of the tillage systems indicates N immobilization is not a factor in explaining why wheat growth on no-till fallow fails to respond to the added soil water conserved for winter wheat-fallow crop management systems in the Central Great Plains.

Although not proven, it appears that the cool soil temperatures that predominate in the Central Great Plains area from fall planting until late spring may not be conducive to N immobilization. Most N fertilizer is applied during this time and any precipitation received probably moves applied N into the soil past the zone of organic matter or residue accumulation where immobilization would occur. Even though the applied N is in contact with organic matter during this time, soil temperatures may be apparently too low for much biological activity to occur.

Table 1. Effects of fallow method on dry matter yield, N concentration, and N uptake of winter wheat straw and heads at physiological maturity and grain at final harvest (averaged across N rates and years).

Fallow Method	June Straw	June Heads	July Grain
		Dry-matter yield, Mg ha^{-1}	
No-till	3.85	2.01	2.11
Stubble mulch	4.18	2.30	2.09
Plow	4.79	2.63	2.43
$LSD_{0.05}$	0.30	0.18	0.13
		N concentration, g kg^{-1}	
No-till	5.9	16.4	20.6
Stubble mulch	6.2	16.6	21.5
Plow	6.8	17.2	22.8
$LSD_{0.05}$	0.8	NS	0.9
		N uptake, kg ha^{-1}	
No-till	21.1	29.7	43.3
Stubble mulch	24.5	34.6	44.4
Plow	29.9	41.2	54.2
$LSD_{0.05}$	3.9	4.5	4.2

Table 2. Effects of N rate on dry matter yield, N concentration, and N uptake of winter wheat straw and heads at physiological maturity and grain at final harvest (averaged across tillage treatments and years).

N Rate	June Straw	June Heads	July Grain
-kg ha^{-1}-		Dry-matter yield, Mg ha^{-1}	
0	3.85	2.17	2.13
45	4.69	2.46	2.29
Significance	**	**	**
		N concentration, g kg^{-1}	
0	5.1	15.7	19.7
45	7.5	17.7	23.5
Significance	**	**	**
		N uptake, kg ha^{-1}	
0	18.2	30.9	41.3
45	32.2	39.4	53.3
Significance	**	**	**

**-Significant at the 0.01 probability level.

Table 3. Effects of fallow method on dry matter yield, N concentration, N uptake, ^{15}N depletion, depleted ^{15}N uptake, and N fertilizer recovery of winter wheat straw and heads at physiological maturity and grain at final harvest (averaged across placement method and years).

Fallow Method	June Straw	June Heads	July Grain
	Dry-matter yield, Mg ha^{-1}		
No-till	4.15	2.08	2.13
Stubble mulch	4.81	2.53	2.26
Plow	5.15	2.78	2.39
$LSD_{0.05}$	0.59	0.29	0.23
	N concentration, g kg^{-1}		
No-till	7.6	19.6	22.0
Stubble mulch	7.9	19.1	23.5
Plow	8.9	20.4	24.9
$LSD_{0.05}$	0.9	1.1	1.4
	N uptake, kg ha^{-1}		
No-till	29.2	36.0	46.5
Stubble mulch	36.1	43.6	53.2
Plow	42.4	51.5	58.9
$LSD_{0.05}$	5.3	6.7	5.8
	Atom % ^{15}N		
No-till	0.297	0.303	0.304
Stubble mulch	0.296	0.297	0.307
Plow	0.291	0.298	0.300
$LSD_{0.05}$	NS	NS	NS
	Depleted ^{15}N uptake, kg ha^{-1}		
No-till	5.9	6.3	7.8
Stubble mulch	7.0	8.3	8.9
Plow	8.7	9.1	10.1
$LSD_{0.05}$	1.4	1.7	1.6
	Fertilizer N uptake, %		
No-till	13.2	14.1	17.4
Stubble mulch	15.6	18.5	19.8
Plow	19.4	20.3	22.6
$LSD_{0.05}$	3.2	3.8	3.5

Table 4. Effects of N placement on dry matter yield, N concentration, N uptake, ^{15}N depletion, depleted ^{15}N uptake, and N fertilizer recovery of winter wheat straw and heads at physiological maturity and grain at final harvest (averaged across tillage methods and years).

N Placement	June Straw	June Heads	July Grain
		Dry-matter yield, Mg ha^{-1}	
Broadcast	4.69	2.46	2.29
Injected	4.72	2.46	2.23
Significance	NS	NS	NS
		N concentration, g kg^{-1}	
Broadcast	7.9	19.5	23.5
Injected	8.4	19.9	23.4
Significance	NS	NS	NS
		N uptake, kg ha^{-1}	
Broadcast	34.4	42.7	53.3
Injected	37.4	44.7	52.5
Significance	NS	NS	NS
		Atom % ^{15}N	
Broadcast	0.298	0.302	0.306
Injected	0.291	0.296	0.302
Significance	NS	NS	NS
		Depleted ^{15}N uptake, kg ha^{-1}	
Broadcast	6.7	7.7	8.7
Injected	7.7	8.1	9.1
Significance	NS	NS	NS
		Fertilizer N uptake, %	
Broadcast	15.0	17.2	19.5
Injected	17.1	18.0	20.3
Significance	NS	NS	NS

ON THE INFILTRATION CHARACTERISTICS BETWEEN TILLAGE/RESIDUE SOIL CONDITION AND RAINFALL

Authors: Mark Fleming (student assistant), Alice J. Jones, Elbert C. Dickey, Kenneth Hubbard and Lloyd Mielke.

Objective: To predict initial and final infiltration and an aggregate coefficient using infiltration versus time data.

Procedure: Data sets, consisting of infiltration versus time were statistically analysed using the non-linear regression package, NREG77. The three parameter model statement Y = 1 a + b * exp (-ct). This equation was derived from the infiltration equation $I_t = I_f + (I_i - I_f)$ exp ($-\gamma$ Pt) where I_t equals infiltration rate at time t, I_f and I_i equal the final and initial rainfall intensity respectively, and equals the empirical aggregate soil resistance coefficient.

When the program to access NREG77 was run, initial parameter estimates for a, b, and c were entered. A best fit model was obtained. From the parameter estimates, the initial and final infiltration rates and the aggregate resistance coefficient were calculated.

Results and Discussion: The NREG77 program provided good results for most of the data sets tested. Results from one replication of Keith soil for three residue/tillage conditions and three soil conditions are presented in Table 1.

In these preliminary results, initial and final infiltration were higher for no crust than for the wet or dry crust conditions. The aggregate resistance coefficient was markedly higher with 0% residue for the no and wet crusts but were similar for the dry crust.

Following the analysis the data I_f, I_i and γ will be statistically compared for each of four soils (Keith, Sharpsburg, Valentine, Holdrege) with three tillage/residue conditions and three soil conditions.

Table 1. Model paramaters for three soil conditions and three residue treatments on a Keith soil. Values represent a single replication.

Condition	Residue	Initial Infil (cm/hr)	Final Infil (cm/hr)	Gamma	Rainfall Intensity (cm/hr)
No Crust	0%	18.20	3.09	10.30	7.77
	30%	11.36	2.23	2.60	8.46
	60%	10.48	2.59	5.52	8.18
Wet Crust	0%	8.16	2.82	17.53	8.32
	30%	7.75	2.25	6.57	8.19
	60%	10.02	2.77	8.74	8.58
Dry Crust	0%	9.75	3.29	8.70	8.18
	30%	7.88	2.94	9.17	8.06
	60%	10.76	2.69	8.03	7.22

TILLAGE INFLUENCE ON SOYBEAN PRODUCTION

Julie Baumert-Powers (graduate student) Alice J. Jones,
Lloyd Mielke, and Jim Specht

Objective: To quantify the dynamic relationship between tillage, rhizosphere characteristics and soybean production for use in developing management strategies which will maximize production efficiency and profits. Specifically:

1) to evaluate effects of tillage on soil water and soil heat processes,

2) to determine the influence of tillage on patterns of root growth, plant water status and crop water use for soybeans,

3) to relate the above soil and plant parameters to soybean yield and yield components.

Procedure: Field experiments were initiated by USDA-ARS in 1980 at the Rogers farm east of Lincoln, Nebraska. Soybean production was studied intensively for 3 tillages--moldboard plow, disk, and no-till. Soybeans were grown in rotation with corn on three replications in a randomized complete block design.

Many soil and crop parameters were measured throughout the 1987 and 1988 growing season. Parameters and the method of evaluation are as follows:

Parameter	Method
Residue Cover	Line Transect
Soil Temperature	Thermocouples/data logger
Soil Water	Neutron Probe
Emergence	Plant Counts
Phenology	Crop Staging
Osmotic Potential	Thermocouple Psychrometer
Water Potential	Pressure Chamber
Yield	Harvest Samples
Seeds per Pod	Hand Counted

Results and Discussion:

Approximately 20 cm less precipitation was received during the 1988 growing season, compared to 1987. Many results of this experiment reflect the different growing conditions between years.

Residue cover after planting for 1987 and 1988 were as follows: plow, 12% and 14%, disk, 34% and 45% and no-till 75% and 80%. Soil temperature was affected by surface residue because of solar radiation reflecting off of residue. Plow treatments had 1 to 2 C° higher soil temperatures at 10 cm depth than no-till in both 1987 and 1988 (Fig. 1 and 2). In 1987, however, disk soil temperatures were similar to plow temperatures while in 1988, disk was similar to no-till. The differences in soil water content between 1987 and 1988 may have affected these soil temperature differences in the disk treatment.

No significant differences were found in the number of days from planting to 50% and 100% emergence in either year of the study. There was less than 3 days difference between tillages in days from planting to specific growth stages throughout the growing season in 1987 and 1988.

Trends in water potential, an indicator of plant water stress, followed patterns of rainfall events in both years. Leaf osmotic potentials followed trends in water potential closely. Readings became more negative as plants were stressed (Fig. 3 and 4). No significant differences were found between tillages in either year in water potential or leaf osmotic potential.

Water use efficiency was calculated by dividing the grain yield by the amount of water the plants used during the growing season. No-till was consistant in water use efficiency in 1987 and 1988 (Table 1). Under drought conditions, plow treatments were less efficient in using water and produced lower yields than disk and no-till. When soil water content was adequate in 1987, yields for all tillages were comparable.

Table 1. Soybean yield and water use efficiency for three tillage treatments 1987 and 1988.

Date	Treatment	Yield	Water Use Efficiency
		kg/ha	kg/cm
1987	Plow	2374.1	38.8
	Disk	2109.6	35.1
	No-till	2091.9	34.8
1988	Plow	986.6	28.4
	Disk	1442.2	41.8
	No-till	1224.3	34.5

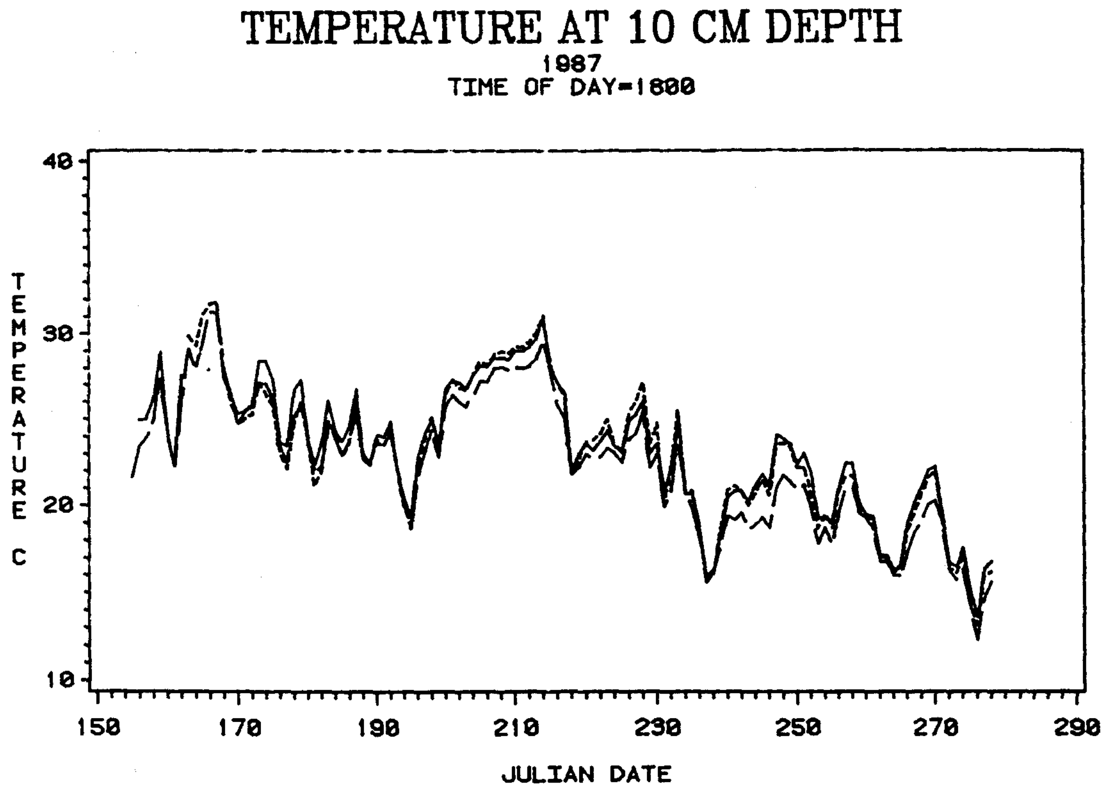


Figure 1. 1987 average afternoon soil temperatures for three tillages at 10 cm depth.

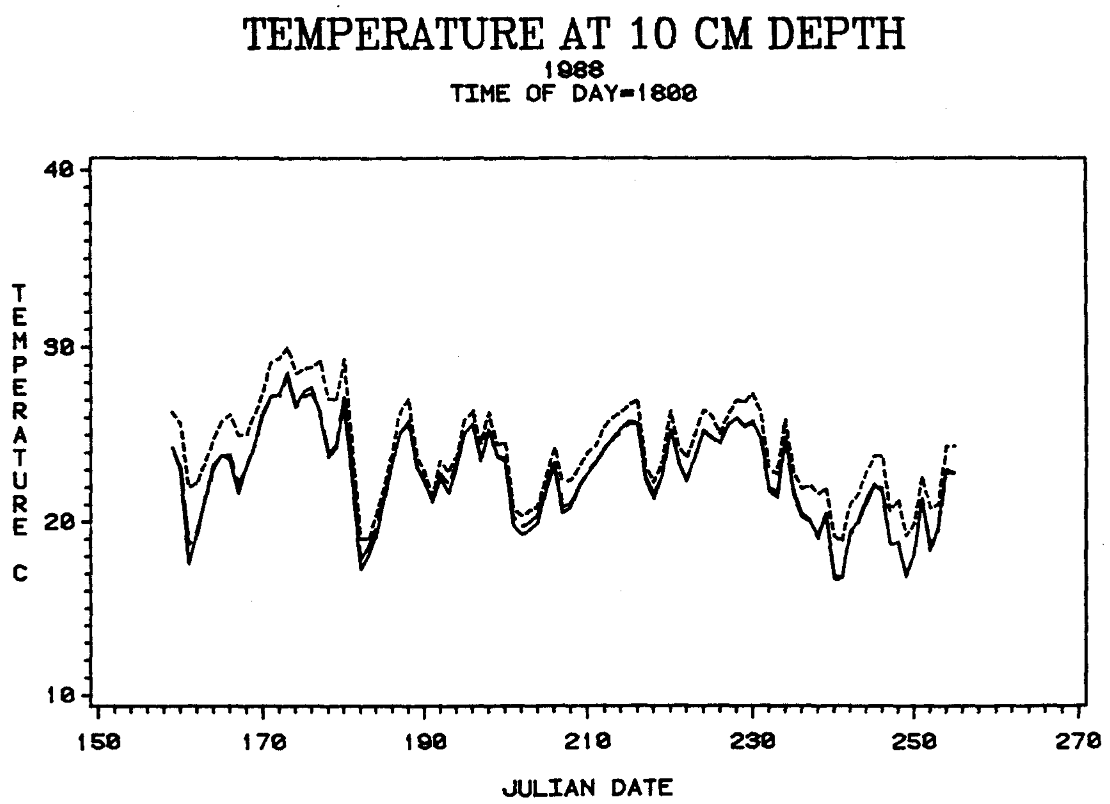


Figure 2. 1988 average afternoon soil temperatures for three tillages at 10 cm depth.

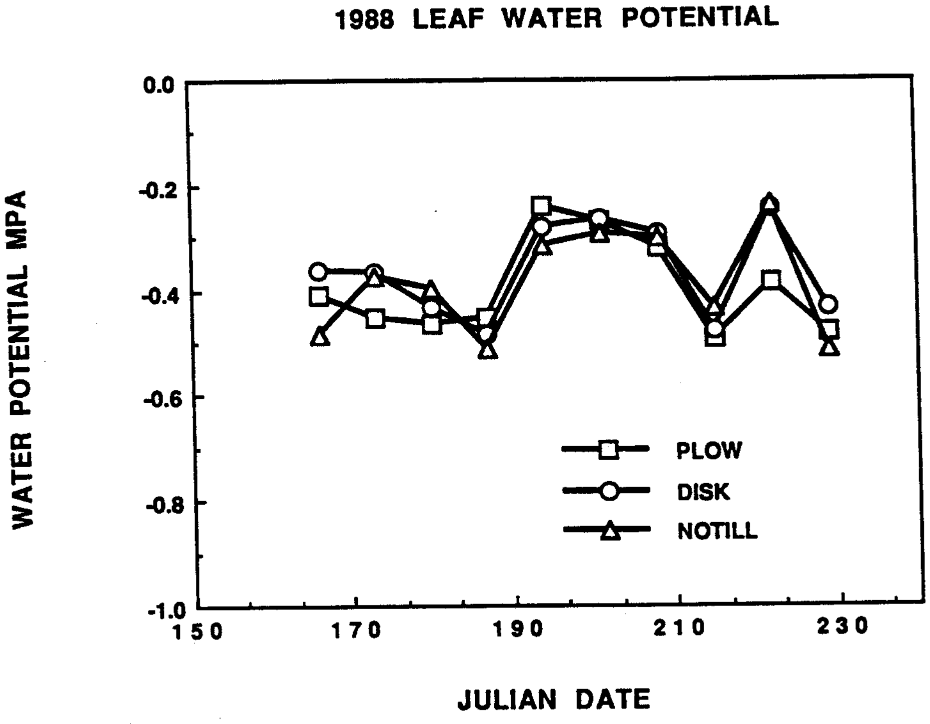


Figure 3. Soybean leaf water potentials for three tillage treatments in MPa.

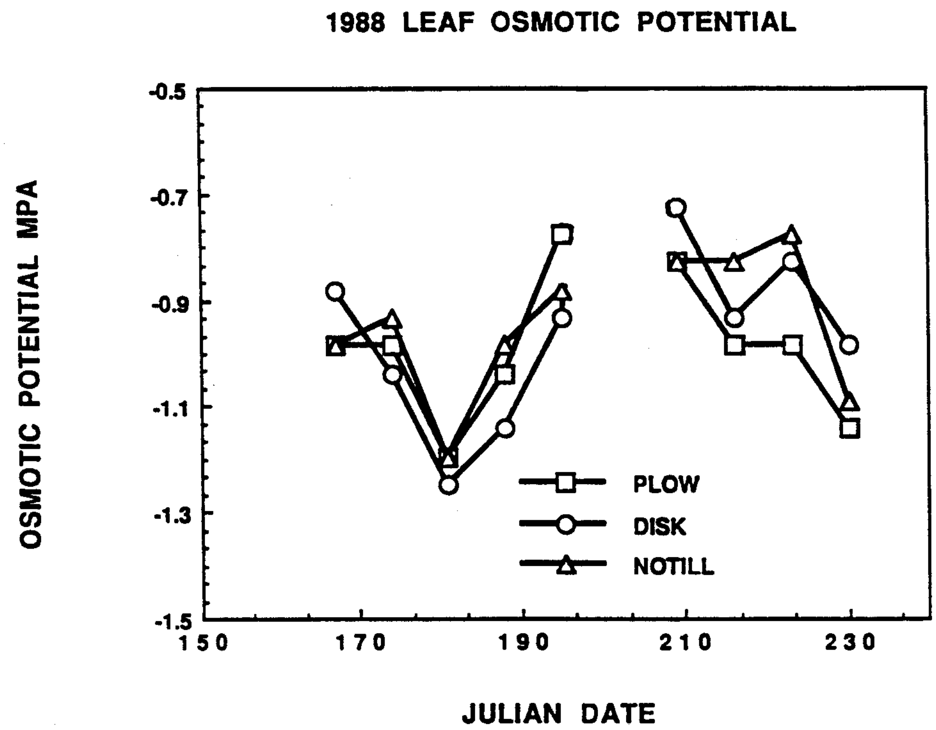


Figure 4. Soybean leaf osmotic potentials for three tillages in MPa.

Tillage, Rotation and N Rate Effects on Dryland Corn Production and Nitrogen Uptake in Northeastern Nebraska

D.T. Walters and C.A. Shapiro

Objective:

To determine the effects of tillage on corn yield and N use efficiency when grown in rotation with soybeans or continuously with or without a hairy vetch cover crop.

Procedures:

Three corn crop sequences: continuous corn (CC), corn-soybean (CB) and continuous corn with a hairy vetch (Vicia villosa) cover crop (CCV) were established in 1985 under three tillage systems (spring disk (DK), spring plow (MP) and no-till (NT)) at the Northeast Research and Extension Center, Concord, NE. Five N rates (0, 40, 80, 120 and 160 kg n/ha) within each tillage x cropping system were applied annually as broadcast NH_4NO_3 prior to tillage in the spring. This experiment was designed as a split-split plot RCB with tillage as main plots (100' x 210'), rotations as subplots (100' x 35') and N rates as sub-subplots (20' x 35'). Soil type is a Kennebec silt loam (Cumulic Hapludoll).

Corn (Pioneer 3475, 110d RM) was planted on May 17 at 46,500 plants/ha in 0.75 m rows. Counter was applied to all corn for rootworm control. Century 84 soybeans were planted on May 26 at 90 kg seed/ha. Weeds were chemically controlled on all plots with the addition of a cultivation in the DK and MP treatments in June. Corn grain and stover were hand harvested from 12 m of row on September 22. Soybeans were combine harvested on October 5.

Madison hairy vetch seed was broadcast into standing corn on August 10, 1987 and a full stand of vetch resulted in the fall of 1987. Vetch dry matter production was evaluated prior to tillage operations on May 4, 1988 by taking a 100 point line intersect count in each plot and multiplying the count by drymatter harvested from five 1 ft^2 areas. Vetch was successfully killed prior to tillage by treatment with 2-4-D. Residual soil NO_3^--N was determined to 1.2 m depth in soil samples from all plots that had received 0, 80 or 160 kg N/ha in 1987.

Results:

An extremely dry spring resulted in delayed spring vetch growth in 1988 (Table 1). Vetch establishment in the DK and MP tillage systems was significantly improved over NT and averaged 0.85 and 0.15 Mg/ha for DK, MP vs NT systems, respectively. Nitrogen rate had no apparent effect on the N content or yield of vetch. To date, broadcast seeding of vetch has resulted in sporadic cover and establishment especially with the high residue cover in the NT system. In the fall of 1988, CCV plots were split to include a comparison of broadcast seeding vs direct drilling of vetch seed after corn harvest.

Residual soil NO_3^--N concentrations were significantly reduced when corn was rotated with soybean, or when vetch was overseeded in the continuous corn system (Figure 1). The level of residual NO_3-N in the CB and CC rotations is directly proportional to the number of corn years in the three years prior to 1988. The difference among <u>B</u>C, <u>C</u>B and CC rotations in residual soil NO_3-N content reflects one, two and three years of N application, respectively, as well as the propensity of soybean to utilize residual soil NO_3-N at the expense of symbiotic N_2 fixation. The inclusion of vetch in the continuous corn system also resulted in a reduction in the amount of residual NO_3-N when compared to continuous corn without vetch. Tillage systems had no effect on residual soil NO_3-N.

Corn grain yields were very poor in 1988 as a result of subnormal precipitation over the 1987-88 winter and during the 1988 growing season. Overall grain yields averaged 2.48 Mg/ha (47 bu/A) for corn and 1.66 Mg/ha (28 bu/A) for soybean. An analysis of variance for selected variables is presented in Table 2.

Severe crop stress in 1988 resulted in abnormally low grain/stover ratios. Grain yield was reduced as available soil water was depleted as the growing season progressed. The added advantage of high surface residues for soil water conservation in the NT system resulted in a significant yield advantage for NT over DK or MP systems (Table 3). The effect of NT on grain yield is reflected in higher grain/stover ratios and significantly lower number of barren stalks. However, regardless of tillage system, when corn followed soybean, grain yields averaged 1.3 times more than either CC or CCV systems. This is consistent with rotation effects on corn grain yield observed in the years 1985-87. As a result of high residual soil NO_3-N and crop stress, there was no yield response to the application of N fertilizer and an actual reduction in yield under the MP system.

Fertilizer N use efficiency (FUE) as measured by the ratio:

$$\frac{\text{Grain N removed (fertilized - check)}}{\text{Fertilizer N rate}}$$

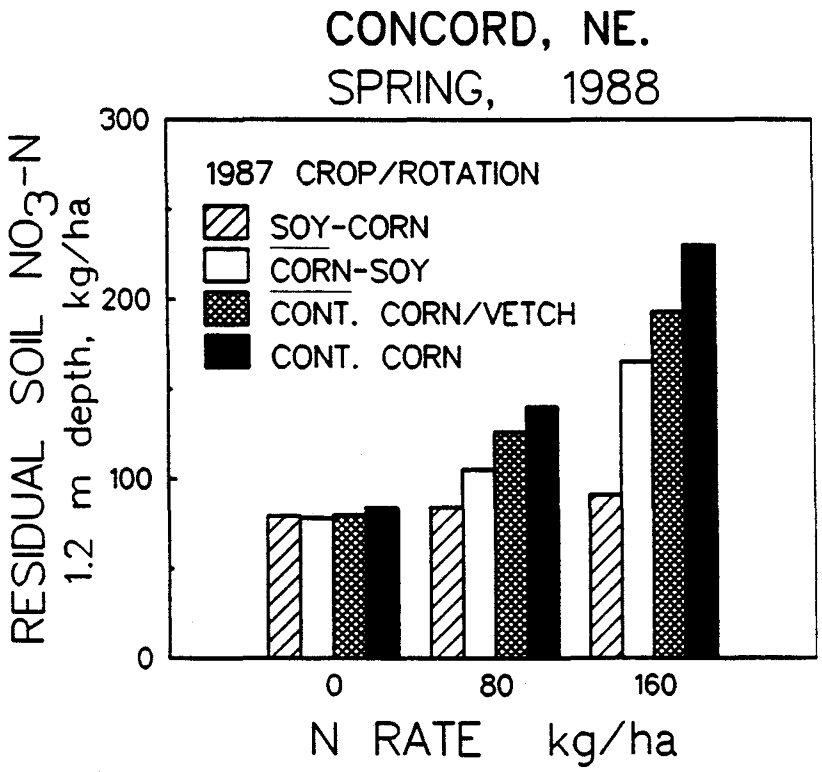
are presented in table 3. FUE averaged 8.3, 0, and 0 percent for the DK, MP and NT systems, respectively. The low FUE recorded this year resulted from high residual NO_3-N, poor grain yield, and an inability of the corn crop to transfer N from vegetative tissue to grain because of stress.

Stover yield reflects the quantity of crop residue left for erosion protection and represents the portion of the corn crop left in the field to cycle nutrients back to the soil. The results in Table 4 indicate that only under NT was there a linear increase in stover production with increasing N rate. Stover N concentrations were abnormally high in 1988 averaging 2.8 percent. As a result, nearly three times more N was cycled through corn stover in 1988 than in previous years. Stover N concentrations were lowest following soybeans however stover yields following soybeans were significantly greater than those from CC or CCV systems. Stover N concentrations and N removal, unlike N in grain, increased linearly with N rate and reflects adverse weather conditions on the translocation of N from the stalk to the grain.

In summary, extremely dry and hot drought conditions in 1988 resulted in average corn grain yields of 2.48 Mg/ha (47 bu/A). Available soil moisture conservation under no-tillage resulted in a 35% yield increase over the DK and MP systems. Regardless of tillage system employed, corn in rotation with soybean yielded 1.3 times more grain than continuous corn. A reduction in total N applied in the CB rotation over the past three years (as compared to CC) has resulted in a very significant decline in residual soil NO_3-N levels and suggests that the CB rotation will lessen the environmental impact of fertilizer N use on groundwater. Although soybeans increase the hazard of soil erosion, there is no advantage to tillage of soybean residues prior to planting corn and the practice of continuous no-tillage in a CB system should reduce this hazard significantly. Surface broadcast seeding of hairy vetch has not been successful especially under NT. Direct drilling of vetch seed will be evaluated in the 1989 growing season. The use of vetch as a cover crop in continuous corn provided some fall cover but did not result in any yield advantage over continuous corn.

Table 1. Vetch yield and N content, CCV plots, spring 1988. Concord, NE.

	Cover	Above Ground Dry Matter	N	N Content
	%	kg/ha	%	kg/ha
Tillage				
Disk	30	840	3.73	30
Sp. Plow	30	860	3.61	31
No-till	11	150	4.28	6
N-rate (kg/ha)				
0	22	550	3.71	20
40	26	710	3.91	26
80	22	620	3.92	23
120	21	530	3.92	19
160	26	670	3.90	24
		Analysis of Variance		
Source				
Tillage	.02	.05	.01	.03
No-till vs Rest	.005	.02	.005	.01
N rate	NS	NS	NS	NS



ANOVA

Prob > F	
Till	NS
Rot	.001
Till x Rot	NS
NR Lin.	.001
Rot x NR	.001
TillxRotxNr	NS

Figure 1. Residual soil NO_3-N to a depth of 1.2 m spring 1988, Concord, NE.

Table 2. Analysis of variance for selected variables, tillage x rotation x N rate. Concord, NE. 1988.

Source	df	Grain Yield	Grain Gr.N(%)	Grain N Removed	Popula-tion	Stover Yield	Stover N(%)	Stover N removed	Barren Stalks(%)	Gr/St ratio	Soybean Yield
		----------	----------	----------	----------	Prob > F	----------	----------	----------	----------	----------
Tillage	2	.002	.04	.001	NS	.009	.05	NS	.005	.001	NS
Rotation	2	.02	NS	.002	NS	.02	.001	NS	.001	.03	--
CC vs CCV	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	--
CB vs CC+CC	1	.006	NS	.001	NS	.005	.001	NS	.001	.02	--
Till x Rotation	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	--
N Rate	4	NS	NS	NS	NS	NS	.001	.006	NS	NS	NS
NR Lin.	1	NS	NS	NS	NS	NS	.001	.001	NS	NS	NS
NR Quad.	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Till x NR	8	.06	NS	.08	NS	NS	NS	NS	.05	NS	NS
Disk x NR Lin.	1	NS	NS	.02	NS	NS	.004	NS	NS	NS	NS
x NR Quad.	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sp. Pl. x NR Lin.	1	NS	NS	NS	NS	NS	.005	NS	NS	NS	NS
x NR Quad.	1	NS	NS	NS	NS	NS	NS	NS	.08	NS	.06
NT x NR Lin.	1	NS	NS	NS	NS	.03	.005	001	NS	NS	NS
x NR Quad.	1	NS	NS	.09	NS	NS	NS	NS	NS	NS	NS
Rotation x NR	8	NS	NS	NS	NS	NS	NS	NS	NS	NS	--
CB x NR Lin.	1	NS	NS	NS	NS	NS	.004	NS	NS	NS	--
x NR Quad.	1	NS	NS	NS	NS	NS	NS	NS	NS	.04	--
CC x NR Lin.	1	NS	NS	NS	NS	NS	NS	04	NS	.06	--
x NR Quad.	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	--
CCV x NR Lin.	1	NS	NS	NS	NS	NS	.03	03	NS	NS	--
x NR Quad.	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	--
Till x Rot x NR	6	NS	NS	NS	NS	.08	NS	07	NS	NS	--

Table 3. Main Effect and 2-way interaction means for corn grain yield, N content, N removal, population, fertilizer N use efficiency and soybean yield, 1988.

Source		Corn Grain Yield*	N	Grain N Removal	Population	FUE	Soybean Yield
		Mg/ha(bu/A)	%	kg/ha	1000/ha	%	Mg/ha(bu/A)
Tillage							
Disk		2.30(43)	2.19	49	45.3	8.3	1.62(28)
Sp. Plow		2.11(40)	2.08	44	43.2	0	1.69(29)
No-till		3.04(57)	2.03	62	43.7	0	1.66(28)
Rotation							
Corn/Soy (CB)		2.95(56)	2.12	62	44.0	4.0	
Cont. Corn (CC)		2.32(44)	2.12	47	44.6	0	
Cont. Corn w/vetch (CCV)		2.18(41)	2.06	45	43.6	0	
N-Rate (kg/ha)							
	0	2.48(47)	2.08	51	43.0	--	1.61(27)
	40	2.42(46)	2.04	49	44.5	0	1.65(28)
	80	2.47(47)	2.04	50	44.2	0	1.66(28)
	120	2.58(48)	2.21	55	44.0	3.4	1.69(29)
	160	2.47(47)	2.13	53	44.8	1.0	1.68(29)
Till x N-rate							
Disk	0	2.10(40)	2.04	43	44.1	--	1.66(28)
	40	2.36(46)	2.11	48	46.3	4.0	1.62(28)
	80	2.42(46)	1.96	48	46.7	12.7	1.55(27)
	120	2.19(41)	2.52	50	44.2	9.2	1.59(27)
	160	2.45(46)	2.35	57	45.1	12.2	1.67(29)
Plow	0	2.21(42)	2.10	46	43.1	--	1.54(26)
	40	1.93(36)	2.00	39	43.8	0	1.83(31)
	80	2.17(41)	2.17	47	41.5	1.0	1.75(30)
	120	2.41(46)	2.12	51	43.9	12.2	1.69(29)
	160	1.83(35)	2.01	38	43.9	0	1.65(28)
No-till	0	3.14(59)	2.12	65	41.8	--	1.64(28)
	40	2.96(56)	2.03	60	43.4	0	1.50(26)
	80	2.83(53)	1.98	55	44.6	0	1.66(29)
	120	3.19(60)	1.96	63	43.8	10.1	1.79(31)
	160	3.12(59)	2.04	64	45.3	7.8	1.70(29)
Till x Rotation							
Disk	CB	2.81(53)	2.15	59	44.1	19.6	
	CC	2.07(39)	2.43	47	46.3	0	
	CCV	2.04(38)	1.98	41	45.4	16.9	
Sp. Plow	CB	2.54(48)	2.15	56	43.4	0	
	CC	2.03(38)	2.01	41	44.1	0	
	CCV	1.76(33)	2.07	36	42.1	0	
No-till	CB	3.50(66)	2.06	72	44.5	0	
	CC	2.88(54)	1.90	54	43.4	0	
	CCV	2.74(52)	2.12	58	43.4	0	
Rotation x N-rate							
CB	0	2.77(52)	2.11	59	42.7	--	
	40	2.90(55)	2.13	60	45.0	2.5	
	80	2.99(56)	2.02	60	43.0	1.7	
	120	3.13(59)	2.27	70	44.2	9.4	
	160	2.96(56)	2.07	63	45.3	2.5	
CC	0	2.61(49)	2.04	52	42.6	--	
	40	2.26(43)	2.02	44	45.8	0	
	80	2.25(42)	2.02	45	44.0	0	
	120	2.26(43)	2.43	49	44.9	0	
	160	2.19(41)	2.10	46	46.0	0	
CCV	0	2.06(39)	2.11	44	43.7	--	
	40	2.09(39)	1.98	42	42.7	0	
	80	2.18(41)	2.06	45	45.9	1.5	
	120	2.32(44)	1.94	45	42.8	0.5	
	160	2.24(42)	2.22	50	43.1	3.5	

*Grain yield as Mg/ha is for dry matter yield, bu/A adjusted to 15.5% moisture for corn and 13% for soybean.

Table 4. Main effect and 2-way interaction means for stover yield, N content and stover N removal, barren stalks and G/S ratio, 1988.

Source	Stover Yield	N	Stover N removal	Barren stalks	Grain/Stover Ratio
	Mg/ha	%	kg/ha		
Tillage					
Disk	3.33	2.77	92	31	0.69
Sp. Plow	3.13	2.88	90	33	0.67
No-till	3.53	2.71	96	19	0.87
Rotation					
Corn/Soy (CB)	3.55	2.65	94	17	0.83
Cont. Corn (CC)	3.18	2.86	91	32	0.73
Cont. Corn w/vetch (CCV)	3.25	2.86	93	35	0.67
N-Rate (kg/ha)					
0	3.31	2.69	88	26	0.75
40	3.23	2.74	88	28	0.74
80	3.34	2.81	94	29	0.74
120	3.45	2.81	97	27	0.75
160	3.32	2.88	95	30	0.73
Till x N rate					
Disk 0	3.36	2.70	89	31	0.65
40	3.23	2.69	86	30	0.70
80	3.44	2.76	95	31	0.70
120	3.26	2.86	93	35	0.67
160	3.35	2.84	95	31	0.72
Sp. Plow 0	3.20	2.76	86	32	0.69
40	2.98	2.87	86	36	0.65
80	3.05	2.91	88	30	0.70
120	3.44	2.84	98	28	0.70
160	2.99	3.00	89	41	0.60
No-till 0	3.36	2.62	87	16	0.92
40	3.46	2.68	92	18	0.86
80	3.55	2.77	98	25	0.81
120	3.67	2.73	100	16	0.89
160	3.65	2.79	101	19	0.86
Till x Rotation					
Disk CB	3.70	2.60	96	19	0.76
CC	3.04	2.92	88	38	0.68
CCV	3.26	2.79	91	37	0.62
Sp. Plow CB	3.31	2.74	91	21	0.76
CC	3.09	2.93	91	37	0.66
CCV	3.00	2.96	88	42	0.58
No-till CB	3.65	2.60	95	8	0.96
CC	3.45	2.72	93	21	0.84
CCV	3.50	2.83	99	27	0.80
Rotation x N-Rate					
CB 0	3.59	2.52	90	16	0.80
40	3.61	2.60	93	16	0.78
80	3.47	2.69	93	16	0.86
120	3.60	2.66	96	15	0.86
160	3.48	2.76	96	19	0.84
CC 0	3.22	2.81	89	28	0.80
40	2.96	2.82	83	32	0.76
80	3.18	2.83	90	31	0.71
120	3.40	2.92	99	33	0.67
160	3.19	2.92	93	35	0.68
CCV 0	3.11	2.76	86	35	0.66
40	3.11	2.82	87	34	0.67
80	3.38	2.91	98	39	0.64
120	3.34	2.87	96	31	0.70
160	3.32	2.94	97	36	0.65

Comparison of Laboratory Procedures for Determination of Potentially Mineralizable Nitrogen

J.S. Schepers and R. Saint-Fort

Objective:

To compare electro-ultrafiltration techniques with other indexes of soil N availability for determination of potentially mineralizable nitrogen.

Procedure:

There is an urgent need for a rapid and reliable laboratory procedure capable of predicting soil N availability from organic matter which represents a source of plant nutrients. When the variability in N-supplying capability of soils is not taken into account, excessive fertilization may lead to less efficient use of N and potential for N pollution of the nation's surface and ground water. Although several soil N availability indexes have been set forth, none of those tests have gained cohesive acceptance in terms of commercial application. Electro-ultrafiltration (EUF) is a relatively recent development in soil science which provides for extraction of NO_3^- and NH_4^+ and of readily soluble N compounds from soils using the principles of ultrafiltration and electrodialysis. These analysis were performed in Germany at the sud zucker (southern sugar) laboratory as part of the soil testing procedure used by the sugar beet industry. Other indexes of N availability evaluated included the anaerobic incubation, autoclave, hot KCl, phosphate-borate buffer, alkaline $KMnO_4$, and $NaHCO_3$-UV methods. A group of 11 SCS benchmark soils from Nebraska were used to cover a range of soil textures and organic matter contents. Laboratory estimates of N mineralization were compared with total N uptake from check plots at several locations in Nebraska.

Results:

There was a wide variation among the procedures tested in their ability to selectively extract an available N pool fraction in soils (Figure 1). Mean N extracted on the average

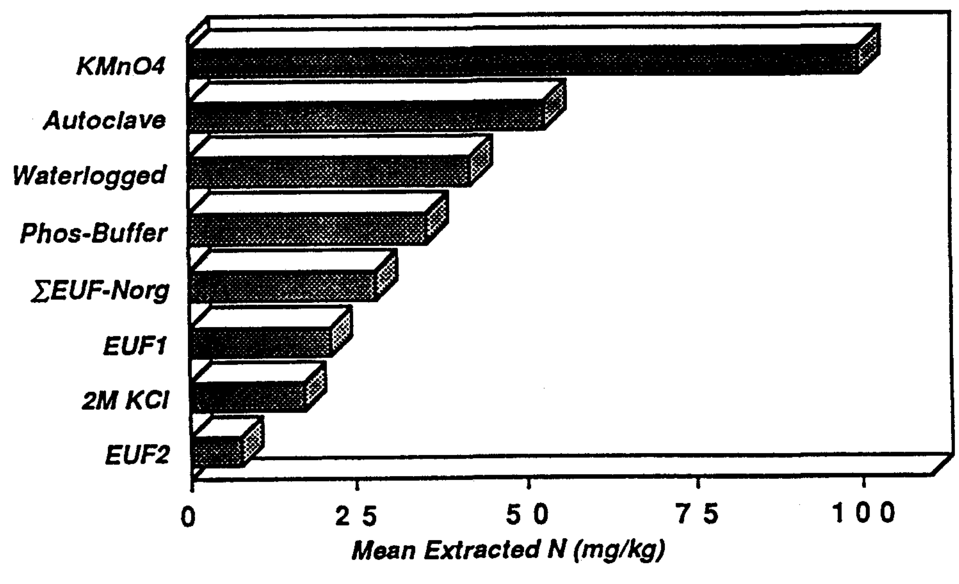


Figure 1. Mean N extracted by the various procedures for 11 Nebraska soils.

ranged from about 7.8 to 100 mg kg^{-1}. Little is known about the type of compounds extracted with individual procedures, but amino acids typically found of microbial cell walls are common in EUF extracts. In the case of the EUF procedure, the EUF_1 and EUF_2 fractions included the non-nitrate compounds extracted from 0 to 30 minutes and from 30 to 35 minutes, respectively. The EUF_1 fraction contained approximately 74% of $EUF\text{-}N_{organic}$, defined as the sum of EUF_1 plus EUF_2. Nitrate-N extracted by the EUF procedure is typically similar to the amount extracted with KCl. The high correlation coefficient (r= 0.98) between EUF_1 and $\Sigma EUF\text{-}N_{organic}$ suggests that the characteristic of the readily available organic N fraction of the organic-N pool in the studied soils are presumably of a similar nature (Figure 2). However, the results

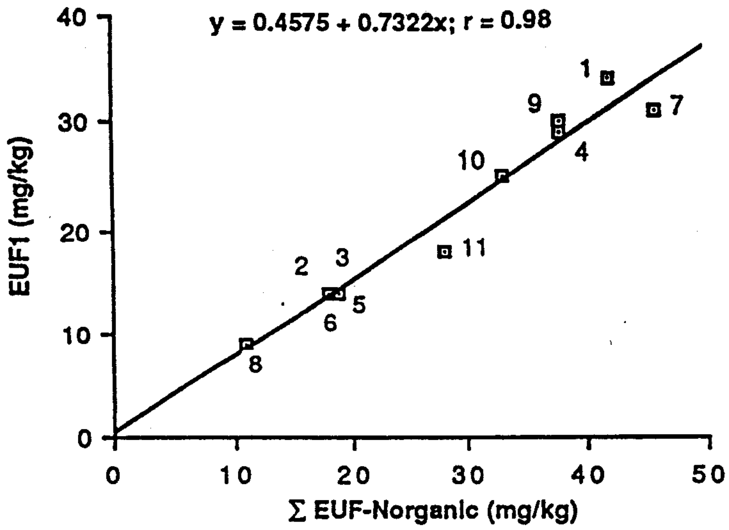


Figure 2. Relationship between $\Sigma EUF\text{-}N_{organic}$ and EUF_1 for 11 Nebraska soils.

obtained with soils # 1, #7 and #11 may be atypical. Soils #7 and #11, which fall into the sandy category and had pH values > 7.4, have an unusually high organic N content. This presumably reflects soil management practices (ie organic wastes application) or landscape position (ie subirrigated meadow) which would concurrently affect the organic-N pool state of both soils. It was further observed that the average releasable N reserves (EUF_2) for soils #7 and #11 were approximately 11 % higher when compared to the average of the other soils (excluding soil #1). This suggests that both soils have probably been enriched with nitrogenous compounds that are not readily oxidized to NO_3^-. Consequently, the effect on N supply to plants and potential for N leaching from the soil N pool at those two sites will be affected by such soil management practice. On the other hand, the releasable N reserve (EUF_2) for soil #1 was only 17% compared to 26% for the mean of all benchmark soils studied. It appears that OM of soil #1 was characterized by a higher fraction of readily mineralizable N compared to the other soils in the investigation. Since soil #1 was under cultivation , it is possible that samples were collected at a time when microbial activity would elevate the EUF_1 value and account for these apparent abnormalities.

Data indicated that the autoclave and EUF procedures were the most highly correlated over the range of benchmark soils studied (Figure 3). Therefore, data from these two laboratory procedures were used to compare with total N uptake by corn. Check plots from locations participating in the University of Nebraska Soil Test Comparison Study (North Platte, Concord, and Scottsbluff) and other related studies (Shelton and Clay Center) were used for this comparison. These soil samples were collected at harvest.

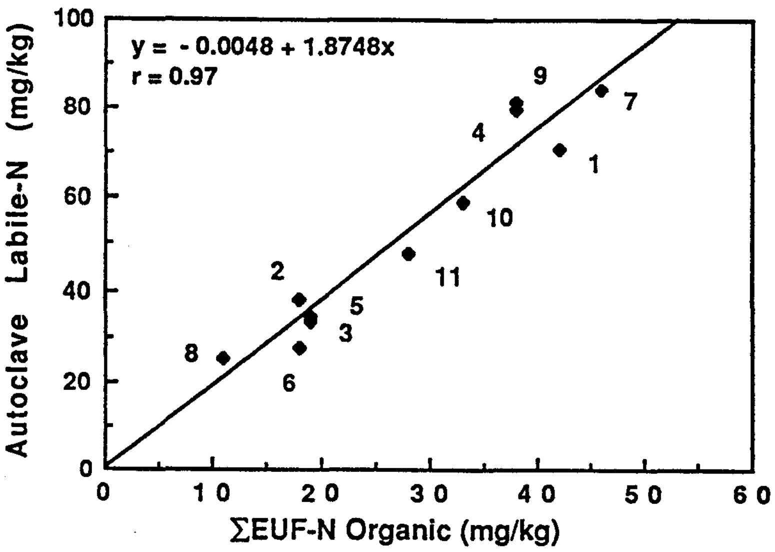


Figure 3. Relationship between EUF-N and autoclave labile-N using SCS benchmark soils.

While meaningful relationships between EUF-extracted N and N uptake were obtained for each location, a composite relationship was not apparent (Figure 4). A similar but less discerning relationship was obtained for the autoclave procedure (Figure 5).

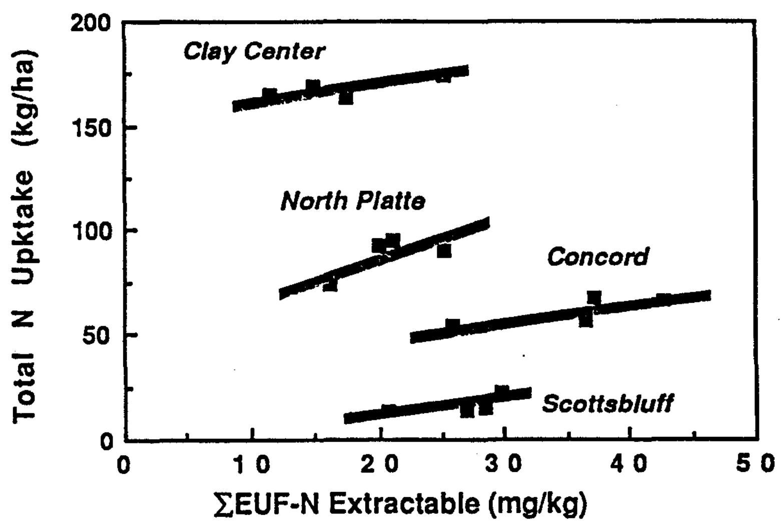


Figure 4. Relationship between EUF extracted organic N and total N uptake by corn check plots.

Multiple regression techniques were used in an initial attempt to "normalize" the locations. The concept of growing degree days (GDD) was used to integrate the effect of temperature over time. Residual N was included in the regression because of location differences at harvest, however residual N levels during the growing season were not known. The regression equations were as follows:

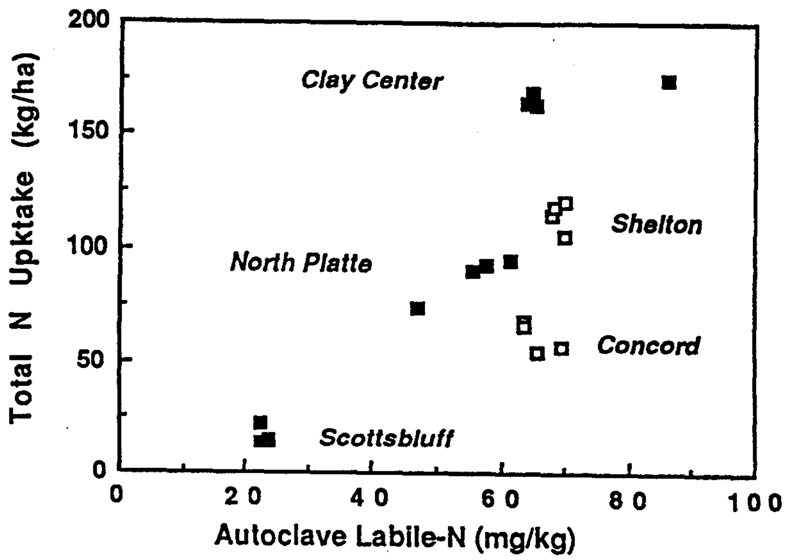


Figure 5. Relationship between autoclave labile-N and total N uptake of corn check plots.

EUF Procedure

N Uptake = -167.5 +0.11(GDD) -2.71($EUF_{nitrate\text{-}N}$) -1.99($EUF\text{-}N_{organic}$) R = 0.95

Autoclave Labile N

N Uptake = -326.0 +0.18(GDD) -1.50($KCl_{nitrate\text{-}N}$) -1.37(Autoclave-N) R = 0.93

These regression equations were encouraging in that GDD is the type of general information available to producers and residual soil nitrate data can be obtained with routine soil testing procedures. Further, we found that autoclave labile-N could be estimated by knowing the soil organic matter content (r^2 = 0.85 and 0.90 for the SCS benchmark soils and the field research site, respectively). Additional adjustments may be required to compensate for differences in soil water, however these research sites were either irrigated or had adequate precipitation during the growing season (1986), so water status could not be evaluated.

Conclusions:

Nitrogen mineralization may be an important aspect of N management depending on the crop being grown, climate, and soil type. Adjustments in fertilizer N recommendations for mineralized N could be based on soil organic matter content and anticipated climatic conditions (temperature and precipitation). Addtitional research will be required to better synchronize N availability with crop N requirements.

Effect of Broadcast Phosphorus on P Response of Ridge-Planted Corn

Gary W. Hergert

Objectives:

1. Determine the broadcast P rate needed to obtain maximum yield of corn on a low phosphorus Cozad silt loam.

2. Determine the effect of annual applications of P on yield response and influence on soil P level.

Procedure:

More ridge-till planted corn is being planted in central and southwest Nebraska every year. Since there is very little tillage in this system one might assume that broadcast phosphorus would be a poor method for correcting phosphorus deficiency. A field at North platte has been in continuous no-till corn production about 20 years and an area in the field was identified with a phosphorus level of 6 ppm Bray-1 P. A phosphorus recommendation depending upon which soil test is used would be somewhere between 40 to 80 pounds of broadcast phosphorus per acre annually according to our current NebGuide on fertilizer suggestions for corn. The phosphorus level in the sub soil was low (4 ppm Bray-1 P) but uniform throughout the plot area.

In the spring of 1985 a P rate study was designed as a five by five Latin Square. P rates were 0, 25, 50, 75, and 100 pounds of P_2O_5 per acre. Plots were 60 feet long by eight-30 inch rows wide. 0-46-0 was broadcast with 180 pounds of N as ammonium nitrate after corn stalks were chopped. Corn was planted with a four row Buffalo till planter. This planter takes off about 5 inches of the ridge by splitting it into the old row covering the chopped corn residue. In all four years the only operation after planting was a ditching the first part of July. In the spring of 1986 the plots were split and half of the plots has received an annual application of the P rate for 4 years.

The grain yield data for the four years showed that an annual P rate of 50 pounds per acre maximized and maintained the yield. The initial 100 pound application maximized yield in 1985 and 1986 but did not produce maximum yield in 1987 and 1988. Yield levels were very high and P removal ranges from 35 to 79 pounds P_2O_5/A in the grain. Phosphorus in the grain was determined all years.

Changes in soil phosphorus level have been checked with routine sampling of the 0 to 8 inch depth mid-way between the row and the furrow. All plots were sampled in 1986 then again in the spring of 1988. Soil test analysis in Table 2 shows the influence of P rates on soil test levels. As noted previously the annual application of 50 pounds of broadcast phosphorus in this ridge-till system was sufficient to maximize yields. However, after three applications the soil test level as an average for the 0 to 8 inch depth was 12.4 ppm. The annual application of 75 pounds phosphorus per acre had increased the soil test level very near the critical level of 15 ppm. There was a very minimal yield increase in 1988 for the 50 pound annual P application compared to the mean of the high treatments. In addition to this sampling a second detailed incremental sampling at 3 inch depths was taken at four locations across the row. Core diameter was

1.5 inches. Two cores per plot for each depth location were composited and analyzed for all individual replications. The 100 pound phosphorus annual and the 100 pound phosphorus residual treatments were sampled. The distributions of phosphorus are shown in Figure 1. Over time with the soil movement that occurs with the ridge-planting and the ditching operation there is sufficient P incorporation to increase the phosphorus level within 4 to 6 inches below the soil surface. Based on the plant response to phosphorus this apparently is adequate to provide the phosphorus needs of the plant.

Table 1. Effect of P rate on grain yield.

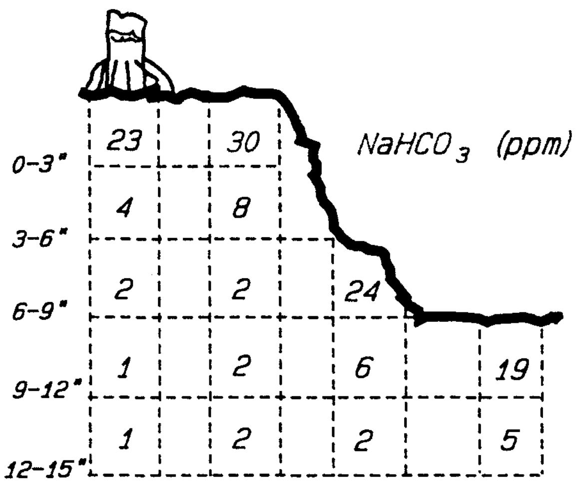
P rate	1985	1986	1987	1988	Avg.	Relative Y
	--------------	--------------	bu/A	--------------	--------------	
Check	145	173	194	163	169	79%
25	160	192	194	166	178	83%
25 annual	160	207	218	205	198	93%
50	178	213	203	175	192	90%
50 annual	178	218	227	215	210	98%
75	180	216	206	180	196	92%
75 annual	180	220	230	218	212	99%
100	186	219	217	185	202	94%
100 annual	186	220	230	218	214	100%

Table 2. Soil phosphorus analysis (0-8") of Cozad silt loam after one and three P applications.

	Spring 1986		Spring 1988	
lbs P_2O_5/A	Bray-1 P	Olsen P	Bray-1 P	Olsen P
	------------------	------------------	ppm	------------------
0	5.8	3.0	6.0	3.0
25 Once	-	-	6.0	3.3
25 Annual	7.6	3.9	7.2	4.2
50 Once	-	-	6.3	3.3
50 Annual	10.9	5.4	12.4	6.9
75 Once	-	-	6.9	3.7
75 Annual	11.4	6.0	14.5	8.3
100 Once	-	-	8.5	4.2
100 Annual	13.5	7.0	16.6	9.0

SPRING 1988
PHOSPHORUS DISTRIBUTION

100# P_2O_5 ANNUAL 1984-87



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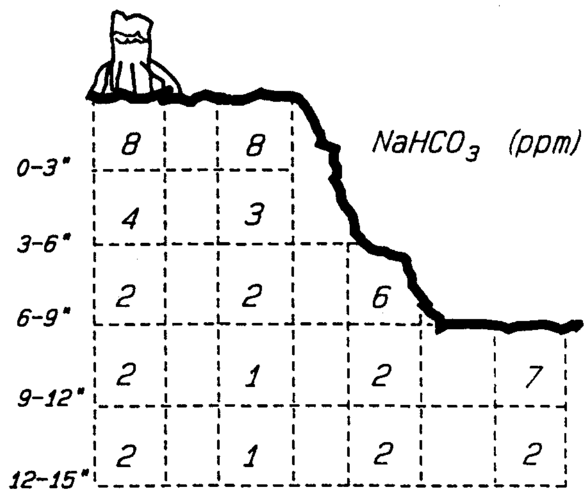

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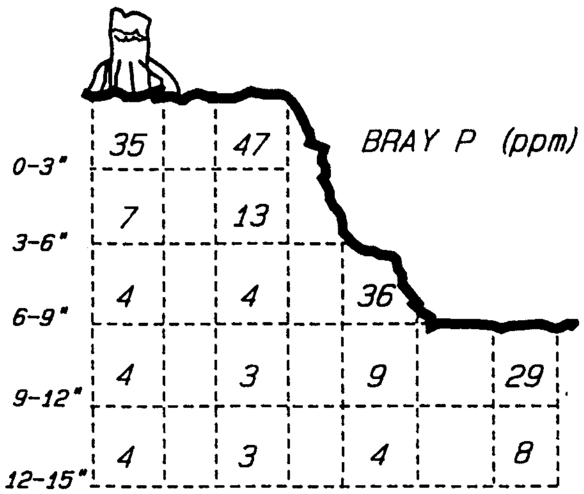

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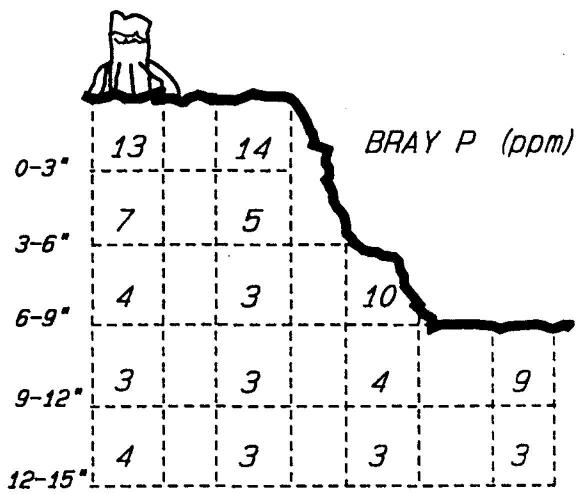


EFFECT OF DATE OF PLANTING ON METHOD OF P PERFORMANCE FOR WINTER WHEAT

D. H. Sander

Objective: To determine if seeding date of winter wheat affects the performance of seed versus dual placement methods of P application.

Procedure: Three experiments were established in the fall of 1987 on low available P soils in Gage (1 location) and Saline County (2 locations). Experimental design involved three seeding dates, two P application methods (knife-dual placed N and P, and seed application) with 3 P rates (9, 18, and 27 kg P ha^{-1}) and a check plot which was also knifed. Plots were 2.4 meters wide by 12 meters long with 0.3 meter between wheat rows. Grain and straw yields were determined from two rows 3 meters in length. Stem counts were made from 60 cm of row. Seed counts and seed weights were determined from 10 heads selected at random. Grain and straw yields only are reported.

Results and Discussion: Grain yields were increased at all three locations with applied P although there was no grain increase past the first increment of P (10 lbs/ac) at location 88-7 in Saline County (Table 1 and 2). Soil P levels (Bray and Kurtz No. 1) were as follows for the 0-4, 0-8, and 8-12 and depths respectively: Location 88-2 (Crete sic) 9.4, 4.6, and 4.6 ppm; Location 88-6 (Eroded Crete Sicl) 9.9, 3.5, and 1.0 ppm; Location 88-7 (Crete sicl) 6.8, 3.0, and 1.2 ppm. Straw yields generally followed grain yield. Date of seeding greatly influenced yield, with grain and straw yields declining severely as planting data was delayed. At two of the three locations, methods of P application significantly interacted with both date of seeding and rate of P application (Table 14). Results indicate that seed application of P was more effective than knife application at later seeding dates. At optimum seeding dates, knife was equal to seed applications of P in terms of grain performance. Knifing P performed especially well compared to seed application at the first planting date of September 22 which is near optimum for southeast Nebraska. Seed application was especially more effective at low rates of application at the Gage County location (88-2).

Table 1. Effect of date of planting of winter wheat on P method of application performance. Southeast Nebraska 1980.

Variable	Location: Gage Co. (88-2) Grain	Straw	Saline Co. (88-6) Grain	Straw	Saline Co. (88-7) Grain	Straw
	---------- kg ha^{-1} ----------					
P Rate-kg ha1						
0	2964	2919	3601	3257	3146	3233
11	3240	3320	3752	3548	3698	3711
22	3611	3625	4116	3955	3866	3865
33	3567	3517	4089	3966	3934	3965
Date 1	3597	3835	4116	4245	4062	4297
2	3813	3751	4095	3764	3887	3798
3	3030	2904	3745	3487	3550	3446
Method						
Knife	3307	3344	3799	3732	3705	3777
Seed	3652	3643	4170	3920	3961	3917
	Analysis of Variance					
Date (D)	.02	.02	NS	NS	.04	.05
Method (M)	.01	.01	.01	.07	.10	NS
Rate (R)	.09	.01	.07	.10	NS	NS
D x M	NS	NS	.01	NS	.02	.11
D x R	NS	.05	NS	.02	NS	NS
M x R	.09	.09	NS	NS	NS	NS
O x M x R	NS	NS	.01	.02	.04	.01

Table 2. Interaction means showing how method of P application performance is influenced by both rate of P application and date of seeding. Southeast NE, 1988.

Seeding Date	P Rate	Location: 88-7 Knife	88-7 Seed	88-6 Knife	88-6 Seed
Days after September 15	kg ha^{-1}	kg ha^{-1}			
6 (9-22-87)	0	3846		3806	
6	9	4109	3840	4311	3772
6	18	3772	4244	4581	3772
6	27	4513	3907	3772	4446
20 (10-6-87)	0	3240		3658	
20	9	3638	3772	3907	3907
20	18	3705	4109	3638	4648
20	27	3907	4177	4042	4513
33 (10-19-87)	0	2344		3341	
33	9	2897	3905	2358	4177
33	18	3705	3705	3974	4177
33	27	3099	3974	3503	4244

EFFECTS OF P FERTILIZER DILUTION IN KNIFED BANDS ON WINTER WHEAT YIELD AND ROOT GROWTH

Tianjia Tang and D. H. Sander

OBJECTIVE: To evaluate winter wheat yield and root growth as affected by liquid P fertilizer distribution in the knifed fertilizer band.

PROCEDURES: In 1987, three experiments were established at three locations to study the effect of P fertilizer distribution on winter wheat yield and root growth. All three selected soils were low in available P as determined by the Bray and Kurtz No. 1 soil test (Table 1). Soils were representative of major soil types in southeast Nebraska being Sharpsburg sicl, Crete sicl and Wymore sicl. Treatments included P rates from 7.5 to 30 kg P ha^{-1} in increments of 7.5 kg ha^{-1} applied in factorial combination with three fertilizer dilutions. Fertilizer dilution involved liquid ammonium polyphosphate (10-15-0) applied non-diluted, diluted equally with water (1:1) or diluted with 2 parts water and 1 part fertilizer (2:1). Fertilizer distribution in the band is shown in Table 2. No P applied treatments were included in the experimental design. This experiment was used at locations 88-10 in Nemaha Co and at 88-7 in Saline Co. At the third location in Nemaha Co., (88-9) all treatments were applied either as a "dual placement" where 10-15-0 and NH_3 were applied together in the band or applied separately. Knifed bands were applied prior to seeding in a spacing of 30 cm. Separate NH_3 and 10-15-0 were applied 15 cm from one another. Wire flags were placed in knife bands 90 cm apart to mark bands for soil sampling. Nitrogen was applied as NH_3 at a rate of 100 kg N ha^{-1} adjusted for the N in the 10-15-0. Plots were 2.3 meters wide by 8.8 meters long with 0.3 meters between rows. Yield was determined from the two center rows 3 meters in length. Spike counts were made from 60 cm of row. Seed counts and seed weight were determined from 30 spikes selected at random.

Soil samples were taken for root determination at heading stage by using a 2.4 cm diameter open face soil sampling tube. Six cores were taken over the fertilizer band to a depth of 20 cm. The top 5 cm was removed and the remaining 15 cm was cut into three 5 cm cores. Root length were measured based on the individual cores.

RESULTS AND DISCUSSION: Wheat yields were surprisingly good in 1988 considering the precipitation received. All three experiments in southeastern Nebraska received 40 to 50% below normal precipitation during the growing season. By early heading, soil was near the permanent wilting point to a depth of 60 cm (Table 1) at all three locations. In fact, surface soil was nearly air dry at the 88-7 and 88-10 locations by flowering time. Soil was extremely hard and soil sampling was not possible without artificial wetting (water was put in infiltration rings to wet soil to a depth of 20 cm). However, at late heading or at pollination all plots received about 10 cm of precipitation. This precipitation, coming at a very optimum time, resulted in yields of 3.5, 4.5, and 3.9 Mg ha^{-1} at locations 88-7, 88-9, and 88-10 respectively (Table 3). Applied P significantly increased yields at locations 88-7 (Crete, eroded) and 88-10 (Sharpsburg, eroded) in spite of the lack of early precipitation which placed wheat under severe early stress (Table 4). While available soil P at location 88-9 was nearly identical to that of the other two soils, applied P did not increase grain yield at this location probably because of much higher levels of available P throughout the soil profile.

The effect of diluting the P fertilizer with water was visually apparent early in the growing season at both locations 88-7 and 88-10 up to approximately the jointing stage of development. Dilution significantly increased both oven-dry weight and plant P concentration at these locations (Table 5 and 6). Significant rate x dilution interactions indicated dilution increased plant dry weight up to the 22.5 kg P ha^{-1} applied P rate. Above the 22.5 kg P rate, all dilutions were continuous bands (Table 2). Early plant concentrations tended to parallel early plant weight in response to dilution. At location 88-9 where applied P did not affect wheat yield, early plant weights were also not affected. However, early plant P concentration was increased as rate of P increased and as dilution increased similar to other two locations.

Root length in the fertilizer band area was significantly increased by applied P and dilution in the 10-14 cm depth where the fertilizer band was placed (data not shown). There was essentially no effect of treatments at the 5-10 cm or 15-20 cm depths.

Table 1. Available soil P (Bray & Kurtz No. 1) and water content to a depth of 60 cm for three experimental locations in southeast NE in 1988.

Depth cm	Crete sicl (eroded) 88-7	Wymore sicl 88-9	Sharpsburg sicl 88-10
	Bray & Kurtz No. P, mg kg^{-1}		
0-15	9.7	10.4	8.5
15-30	10.2	16.7	7.8
30-45	8.7	19.8	7.0
45-60	7.8	15.4	7.0
	Soil Water, percent (early heading)		
0-10	7.5	8.9	11.0
10-20	10.3	10.5	11.5
20-30	12.5	10.3	15.3
30-40	12.7	10.3	15.3
40-50	15.6	14.8	15.0
50-60	12.7	14.8	14.5

Table 2. Effect of rate of P application on P fertilizer distribution in the band according to P rate and dilution.

P Rate	Dilution	Spacing of Droplets
kg ha^{-1}		cm
7.5	0:0 (1)	5.4
15.0	"	1.8
22.5	"	.9
30.0	"	Continuous band
7.5	1 water:1 fertilizer (2)	1.8
15.0	"	Continuous band
22.5	"	"
30.0	"	"
7.5	2 water:1 fertilizer (3)	"
15.0	"	"
22.5	"	"
30.0	"	"

* Dilution is based on solution volume

Table 3. Effect of P rate and dilution on grain yield and yield components on three soils in southeast NE. 1988.

Variable	Yield	Heads/ha x 10^6	Seeds/head	wt/100 seed
	kg ha^{-1}			gram
-		Crete (eroded) sicl (88-7)		
P Rate(kg P/ha)				
0	2082	1.94	31	3.1
7.5	3258	3.70	31	2.9
15.0	3375	3.21	32	3.3
22.5	3508	3.72	32	2.9
30.0	3638	4.22	34	2.9
Dilution[1]				
1	3441	3.71	31	3.1
2	3443	3.76	33	3.0
3	3449	3.66	32	3.1
		Wymore sicl (88-9)		
P Rate (kg P/ha)				
0	4568	4.42	32	3.3
7.5	4402	4.36	32	3.0
15.0	4523	4.53	32	3.2
22.5	4494	4.01	30	3.4
30.0	4500	4.46	33	3.2
Dilution				
1	4517	4.56	32	3.2
2	4454	4.51	32	3.2
3	4468	4.39	32	3.2
N method				
dual	4516	4.42	32	3.2
separate	4444	4.56	31	3.1
		Sharpsburg (eroded) sicl (88-10)		
P Rate (kg P/ha)				
0	3516	2.65	30	3.9
7.5	3678	2.80	32	4.0
15.0	3817	3.00	33	4.0
22.5	3871	3.08	32	4.0
30.0	3935	2.96	32	4.0
Dilution				
1	3874	2.90	33	4.1
2	3794	3.05	32	3.9
3	3808	2.93	31	4.1

[1] 1=0:0; 2=1:1; 3=2:1 (water:10-15-0 dilution)

Table 5. Effects of P rate and dilution on early plant sample yield and P uptake at 88-7 and 88-10 (late tillering).

Variables	Locations			
	88-7		88-10	
	Plant Yield	P Conc.	Plant Yield	P Conc.
	g/60 cm row	mg kg^{-1}	g/60 cm row	mg ha^{-1}
P rate, kg P/ha				
0	18	2173	44	2166
7.5	35	2442	52	2542
15.0	58	2840	72	3088
22.5	61	3344	81	3316
30.0	73	3633	97	3531
Dilution[1]				
1	53	2626	71	2884
2	58	2959	77	3037
3	60	3609	80	3419
		Analysis of Variance		
Rate	0.01	0.01	0.05	0.01
Linear	0.01	0.01	0.01	0.01
Quad	0.01	ns	ns	ns
Dilution	0.01	0.01	0.01	0.01
Dil. 1 vs. 2	0.01	0.01	ns	ns
Dil. 1 vs. 3	0.01	0.01	ns	0.01
Dil. 2 vs. 3	0.09	0.01	0.01	0.01

[1] 1=0:0; 2=1:1; 3=2:1 (water: 10-15-0 dilution)

Table 6. Effects of P rate, dilution, and N method on early oven dry plant weight at 88-9 (late tillering).

Variables	Early Plant Weight	P Concentration
	grams/60 cm row	mg kg^{-1}
P rate, kg P/ha		
0	111	1921
7.5	117	2471
15.0	115	2983
22.5	119 .	3886
30.0	116	4298
Dilution[1]		
1	118	3020
2	118	3519
3	117	3687
N Method		
1 (dual)	117	3338
2 (separate)	116	3480
	Analysis of Variance	
Rate	ns	0.01
Linear	ns	0.01
Quad	ns	ns
Dilution	ns	0.01
Dil. 1 vs. 2	ns	0.01
Dil. 1 vs. 3	ns	0.01
Dil. 2 vs. 3	ns	ns
N method	ns	0.08
Rate*Dilution	ns	0.01
Rate*N method	ns	0.05
Rate*Dilution*N Method	ns	ns

[1] 1=0:0; 2=1:1; 3=2:1 (water:10-15-0 dilution)

EVALUATION OF THE INFLUENCE OF STARTER FERTILIZER ON CORN, GRAIN SORGHUM, AND SOYBEANS, 1988

E. J. Penas, R. A. Wiese, G. W. Hergert, & C. Shapiro

Objective:

Determine the influence of farmer-applied starter fertilizer on plant emergence, early plant growth, grain yield, grain moisture at harvest and final plant populations of corn, grain sorghum, and soybeans.

Procedure:

Cooperating farmers were selected that use starter fertilizer on their row crops. They were asked to leave five strips without starter fertilizer that were each approximately 150 feet in length. Strips were alternated with strips with starter fertilizer (each one-planter width). Thus, each no-starter strip was bordered on both sides with starter fertilizer. Measurements were made on ten pairs of two-row plots. Information was obtained from each farmer to determine the analysis and rate of fertilizer used. County agents collected most of the data prior to harvest. Soil temperature was determined at planting time and again two weeks after planting. Separate soil samples (0-6 inches deep) were collected from each of the no-starter strips. Plant counts were taken in the starter and no starter rows in each of the ten pairs of plots. Plant height measurements were taken 30-40 days after planting. Grain yields for corn were determined by harvesting two 25-foot lengths of row in each of the ten pairs of comparisons (two 15-foot row for grain sorghum and soybeans). Grain moisture was determined at harvest time for corn and grain sorghum.

Experimental Results:

Information was collected from nineteen corn trials, eight grain sorghum trials, and two soybean trials. Data are summarized in Table 1. Locations are listed in order of increasing soil phosphorus. For the corn sites, phosphorus ranged from 7 to 42 ppm phosphorus. For grain sorghum, the range was 8 to 96 ppm phosphorus. The soil for the soybean trials was 9 and 15 ppm P. The nutrients contained in the starter fertilizer that was used are also given in Table 1.

Corn Experiments. Early growth measurements were obtained at fourteen locations, and at nine of these, there was a significant growth response to applied starter fertilizer. This growth response occurred on soils testing as high as 42 ppm P. Only at four sites where soil phosphorus was low to medium (below 25 ppm P) and measurements obtained did starter fertilizer fail to increase early growth. One of these received only N as the starter fertilizer.

Grain yields were good in 1988 with an average yield of 143 bushels per acre. Grain yields from seven non-irrigated sites averaged 101 bushels per acre with a range from 57 to 140 bushels per acre between sites. Grain yields from twelve irrigated sites averaged 167 bushels per acre with a range from 128 to 192 bushels per acre between sites.

Starter fertilizer increased grain yield at four sites out of 19. At three of these sites, soil phosphorus level was 10 ppm or less. The one site in Saunders County that responded to starter fertilizer was medium in phosphorus. Starter fertilizer significantly reduced grain yield at two sites. One of these was high in soil phosphorus. The other site (Holt County) was medium in soil phosphorus and plant population was reduced by the application of starter fertilizer.

Grain moisture at harvest time was reduced by starter fertilizer at four locations; however, reductions were usually less than 1%.

Grain Sorghum Experiments. Starter fertilizer increased early growth of grain sorghum at four of eight sites. Growth response did not appear to be related to soil phosphorus level except where soil phosphorus was very high (96 ppm) and early growth was reduced by starter fertilizer. Starter fertilizer did not increase the grain yield of grain sorghum on any of the sites, and reduced grain moisture at harvest at only one site out of five where measurements were obtained.

Soybean Experiment. The application of starter fertilizer on soybeans had no effect on the growth of soybeans even though soil phosphorus was low at both trial sites.

Table 1. Influence of starter fertilizer applied by producers on early growth, grain yield, and grain moisture of corn, grain sorghum, and soybeans, 1988.

Location	Soil Texture	Soil P, ppm	Soil Zinc Index	Starter Used	Early Growth Increase,%	Yield Increase, bu/ac	Grain Moisture Change,%
			Corn				
Dawson (Stuart)	Loam	7	1.2 (DTPA)	NP	26*	15*	-0.8*
Hayes (Lemon)	Loamy sand	8	3.9 (DTPA)	NPKSZn	--	14*	0.2
Lincoln (WCREC)	Silt loam	10	1.6 (DTPA)	NPZn	26*	10*	-0.5*
Saunders (Hanke)	Si clay loam	10	4.0	NPKSZn	1	- 4	0.0
Furnas (Glanzer)	Silt loam	12	2.8	NP	--	- 1	-1.3*
Dodge (Poppe)	Si clay loam	13	4.4	NPZn	- 3	1	---
Dodge (Parr)	Silt loam	14	6.8	NPZn	9*	- 1	---
Washington (Schneider)	Silt loam	15	6.6	NPKSZn	13*	1	---
Saunders (Sladky)	Si clay loam	16	4.6	NPZn	44*	4*	-0.1
Butler (Medinger)	Silt loam	16	4.9	N	0	- 2	---
Holt (Belik)	Silt loam	17	8.0	NPS	--	-14*	-0.5
Butler (Medinger)	Silt loam	18	5.0	NP	21*	3	---
Nance (Mohr)	Silt loam	22	6.1	NPKSZn	2	1	---
Lincoln (Fritz)	Loam	12 (Olsen)	0.9 (DTPA)	NPZn	2*	7	-0.3*
Washington (Toebben)	Silt loam	27	5.2	NPK	7*	4	---
Cass (Zoz)	Si clay loam	28	6.1	NP	- 2	2	---
Wheeler (Burtwhistle)	Loamy fine sand	30	10.7	NPKS	--	-12*	-1.7
Colfax (Strudl)	Silt loam	42	5.2	NPKS	8*	- 3	---
Hamilton (Parpart)	Silt loam	(42)	---	NP	--	- 1	---

(continued)

Table 1 (continued). Influence of starter fertilizer applied by producers on early growth, grain yield, and grain moisture of corn, grain sorghum, and soybeans, 1988.

Location	Soil Texture	Soil P, ppm	Soil Zinc Index	Starter Used	Early Growth Increase,%	Yield Increase, bu/ac	Grain Moisture Change,%
			Grain Sorghum				
Jefferson (Zabel)	Silt loam	8	---	NPKZn	20*	7	---
Gage (Fritzen)	Si clay loam	17	---	NP	5	- 1	-0.1
Saline (Skleba)	Silt loam	17	---	NPK	5*	- 2	-0.3
Gage (Kier)	Si clay loam	24	---	NPK	0	4	0.2
Johnson (Wolken)	Si clay loam	28	---	NPSZn	19*	0	-0.8*
Cass (Zoz)	Si clay loam	33	5.5	NP	5*	2	---
Saunders (Hellerich)	Si clay loam	42	---	NP	8	2	---
Saline (Schwisow)	Silt loam	96	---	NP	- 6*	4	-0.1
			Soybeans				
Jefferson (Zabel)	Silt loam	9	---	NPKZn	- 2		---
Gage (Fritzen)	Si clay loam	15	---	NP	- 3	0	---

*Significant effect from starter fertilizer (P = .10)

Influence of N-Serve on Nitrogen Management and Crop Response

Gary W. Hergert

Objective: Determine the long term influence of using N-Serve in preplant ammonia for furrow irrigated silt loam soils.

Residual Nitrate Distribution

A nitrogen rate study with and without N-Serve was initiated at North Platte in 1985. Nitrogen rates in 40 pound increments from 0 to 200 pounds of N/A were used with and without 0.5 pounds N-Serve/A. Yield results were published in the 1987 Soil Science Research Report. Three year average yield showed that there was not a significant influence of the N-Serve on the grain yield. Soil samples from selected plots were taken from 0 to 12 feet (water table) by 1 foot increments in the fall of 1987. Data for the check, 80, 160, and 200 pound N rate plots with and without N-Serve are presented in Table 1. The 200 pound N rate was only sampled to a 6 foot depth.

The soil sampling does show that there was more nitrate under the treatments which received no N-Serve. The pattern of distribution of nitrate indicates a similar leaching trend (Fig 1). At the 80 lb N rate there was little enrichment of nitrate below the root zone compared to the check samples. As N rates approach those required to produce optimum yields the amount of N lost is not great but it indicates that some leaching will occur no matter how good the nitrogen or irrigation management is. In general there was a slight increase in nitrate in the root zone to the point where maximum yield occur (Fig 2). The average for the three years show that this was about 160 pounds nitrogen/A to produce an average yield of 196 bu/A. Beyond the point of optimum nitrogen residual soil nitrogen increased rapidly (Figure 2).

Ammonium Nutrition

In 1988 the study was changed to determine the influence of ammonium nutrition on corn yield. Previous N rates were continued on the same plot used from 1985 to 1987. In 1988, however, 30 pounds of preplant N was broadcast over the whole area to provide for uniform early growth. Nitrogen treatments applied were preplant ammonia without N-Serve and sidedressed ammonia with N-Serve in 40 pound increments to 200 lb N/A.

Plant sampling showed that ear leaf nitrogen was higher for those treatments receiving the sidedressed application of N-Serve and anhydrous ammonia (Table 2). However, grain yields showed a different effect. There was a significantly lower yield where the sidedressed N was applied with the N-Serve compared to the preplant ammonia with none (Table 2). Those treatments receiving N-Serve apparently had sufficiently delayed nitrogen uptake that did influence yield (Figure 3). It is obvious from this work that nitrogen release can be delayed sufficiently to decrease the yield potential. The importance of ammonium nutrition for the hybrid used in this study apparently was not off-set by the total uptake of N as it influenced grain yield. In 1989 this study will be changed somewhat and will compare early sidedress ammonia vs early (V-4 to V-6) sidedress with N-Serve.

Table 1. Soil nitrate distributions following three annual N applications in continuous corn at North Platte.

Depth	Check	80 lb	80 lb + N-Serve	160 lb	160 lb + N-Serve	200 lb	200 lb + N-Serve
-ft--	ppm NO_3-N						
0- 1	4.0	4.6	4.5	7.5	6.2	12.3	10.2
1- 2	2.1	2.6	1.8	3.7	3.1	7.9	5.3
2- 3	1.6	1.9	1.3	4.6	2.5	11.7	6.9
3- 4	1.4	1.5	1.1	2.5	1.7	3.8	3.7
4- 5	1.2	1.3	1.2	2.1	1.9	2.7	2.6
5- 6	1.2	1.5	1.0	2.4	2.6	4.9	1.8
6- 7	1.3	1.4	1.4	2.9	3.4	4.9	1.8
7- 8	1.2	1.4	1.3	1.8	3.0	-	-
8- 9	1.1	1.5	1.3	2.2	3.4	-	-
9-10	1.4	1.6	1.7	2.9	3.2	-	-
10-11	1.6	2.0	2.1	3.4	3.9	-	-
11-12	1.6	2.7	2.2	4.0	4.4	-	-

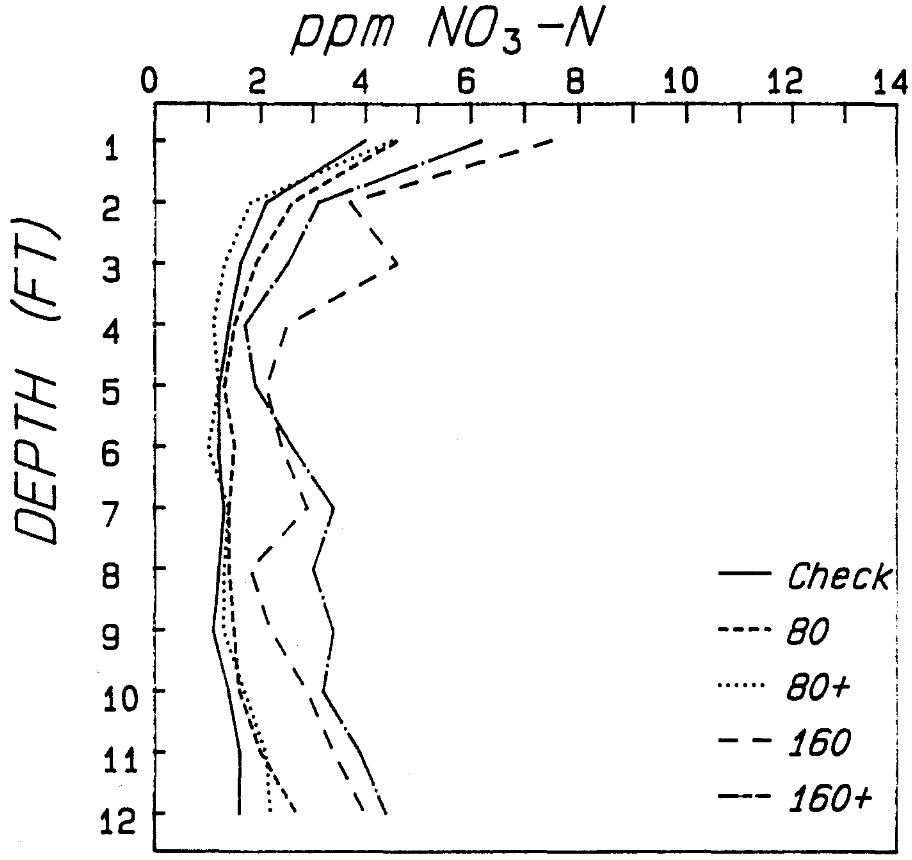
Table 2. 1988 yields and ear leaf N.

N Rate	N-Serve	bu/A	Earleaf % N
30	-	125	1.53
70	-	167	2.20
70	+	161	2.42
110	-	191	2.51
110	+	188	2.66
150	-	200	2.65
150	+	192	2.69
190	-	202	2.74
190	+	187	2.72
230	-	205	2.77
230	+	192	2.80

AOV		
	PR>F	
Source	Grain	Earleaf N
N Rate	.001	.001
N-Serve	.001	.001
Rate x N-Serve	.26	.02
CV	4.8%	3.1%

N-Serve	bu/A	Earleaf % N
With	184	2.67
Without	194	2.57

Figure 1.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Check
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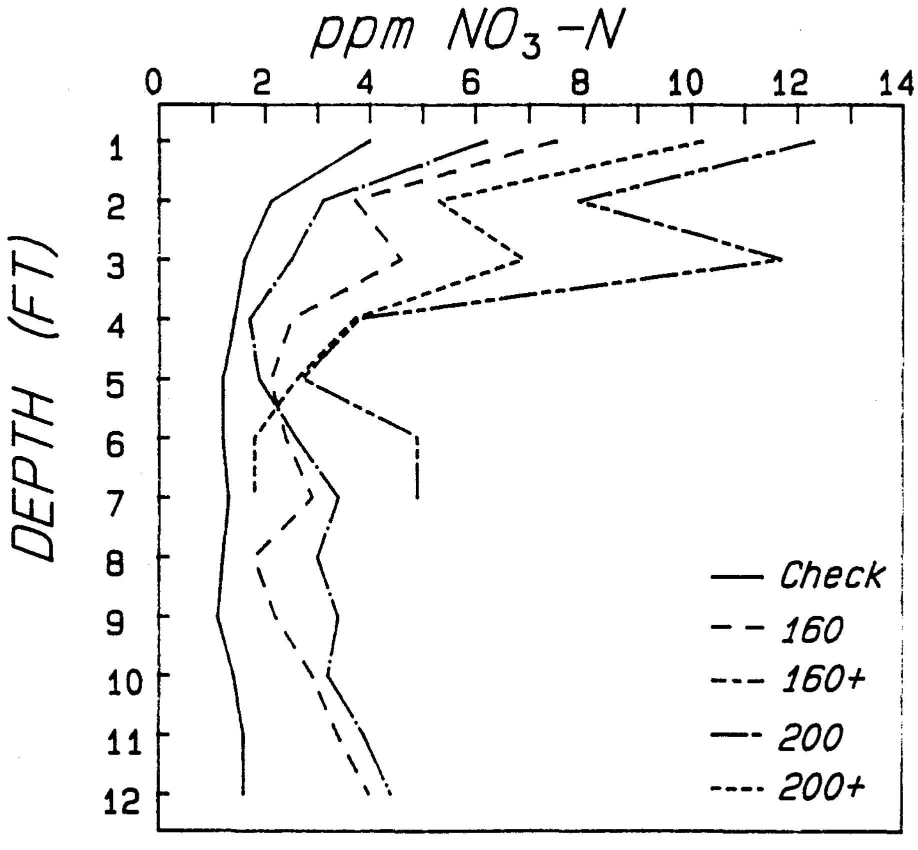
80+
160
160+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DEPTH (FT)
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Check
160
160+
200
200+

Figure 2.

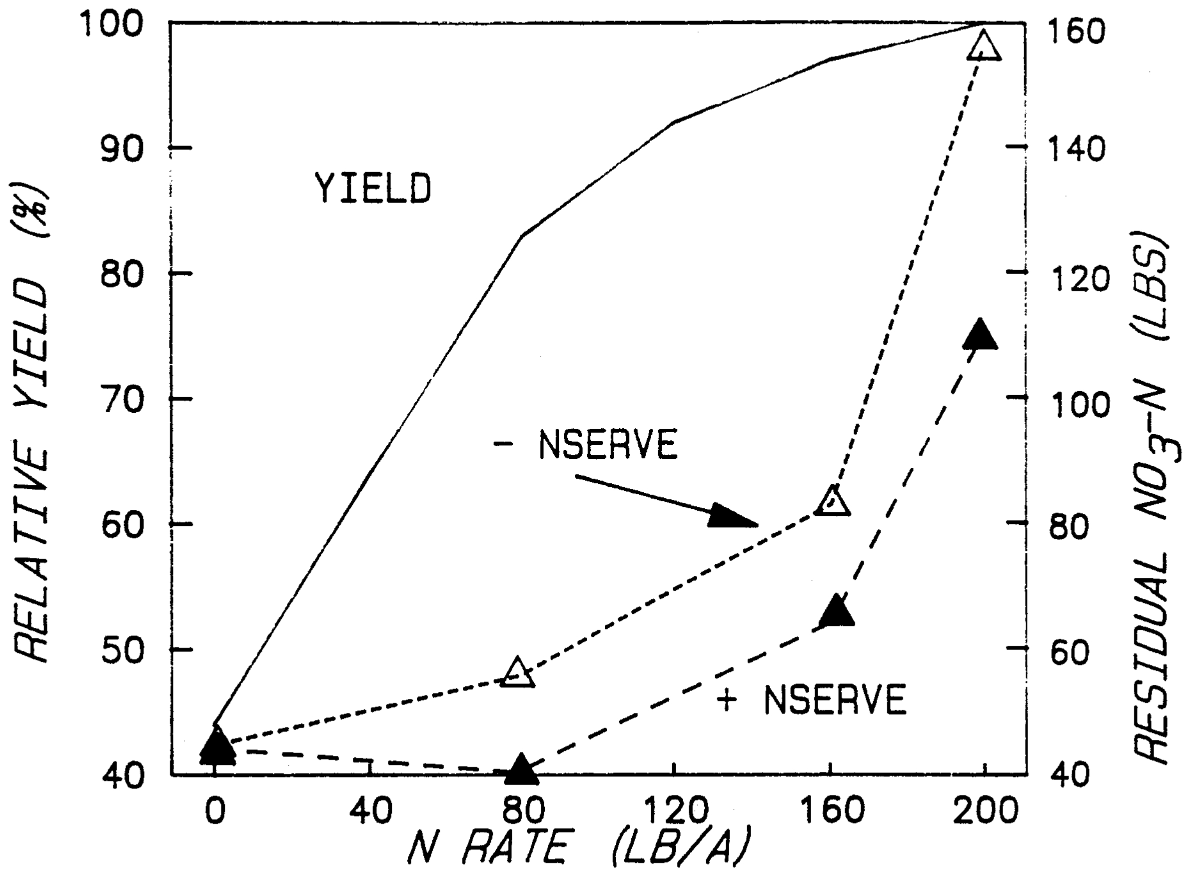
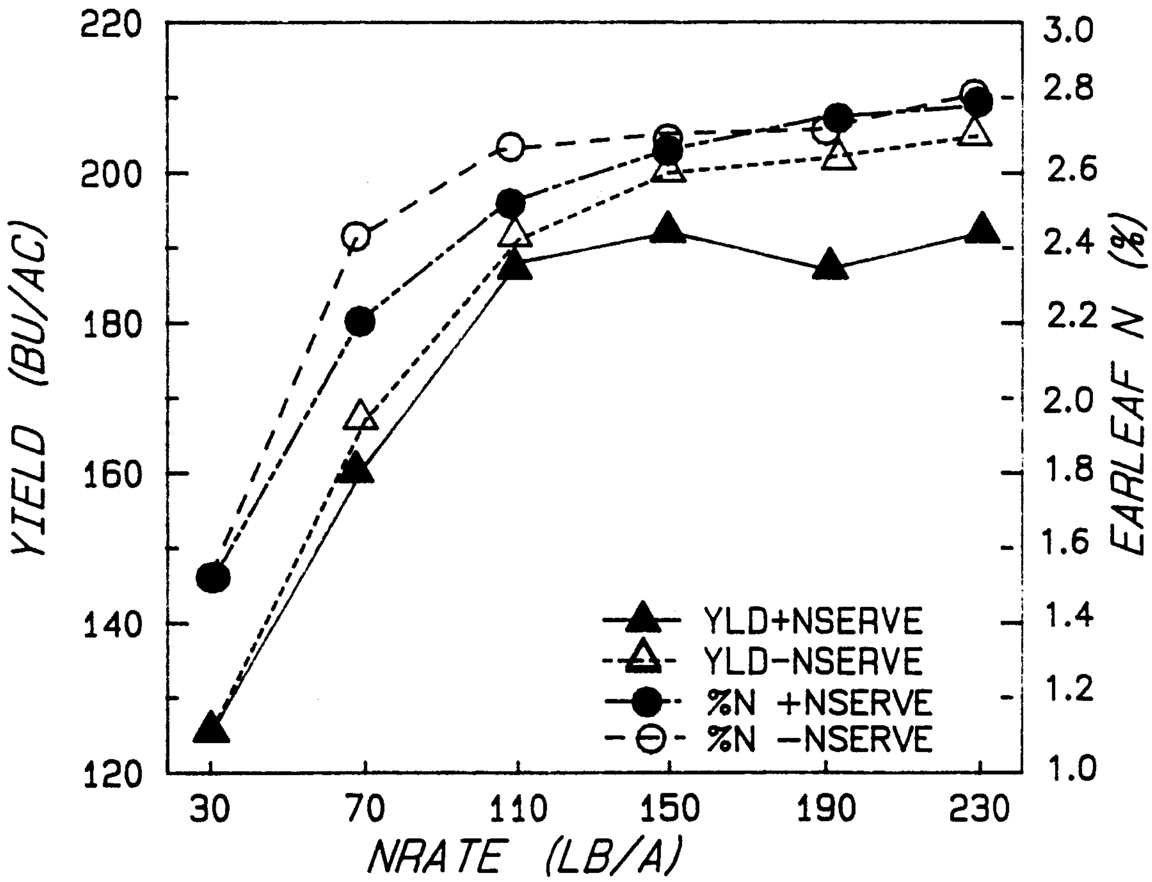


Figure 3.



MANAGING NITROGEN MORE EFFECTIVELY FOR REDUCED COSTS AND ENVIRONMENTAL HAZARDS

C.H. Hartwell, D.H. Sander, and D.T. Walters.

Objective: a) To determine the relationship between spring and early June soil residual nitrate content and nitrogen fertilizer requirements. b) To determine the relationship between corn leaf nitrogen and nitrogen fertilzer requirements.

Procedure: Experiments were conducted at 5 locations in 1988. Three locations were established in Merrick County and one each in Hamilton and Boone county. Locations were selected to provide a range of soil characteristics and a range of nitrate levels in the soil root zone. All sites are irrigated with two sites in Merrick and the one in Hamilton being gravity irrigated. The remaining site in Merrick and the one in Boone were center pivot irrigated. There were six rates of N applies (0, 40, 80, 120, 160, 200 lbs/ac)in three basic N management systems. The first is a split application system with 40 lbs of N applied as preplant and the rest of the rate applied at sidedressing in mid June. In the second system all of the N was applied at sidedress in mid June. In the third system all of the N was applied prior to planting. Ammonium Nitrate was used at all 5 locations. Soil samples were taken to a depth of 6 feet in 1 foot increments for residual nitrate analysis in spring and early June. Samples were taken on plots where no nitrogen was applied. Plant leaf samples were taken at 4 different stages beginning at stage 8 and ending at early silk. Rainfall and irrigation amounts were recorded. All plots were combine harvested for grain yields. Soil analysis for soil nitrate-N has been completed. Leaf N analysis is in process. Data analysis is also in process. Description of experimental conditions is shown in table 1.

Table # 1. Description of experimental conditions.

Location:	Hamilton Co.	Merrick # 1	Merrick #2	Merrick #3	Boone Co.
Soil Type	Holder Silt Loam	O-Neal Sandy Loam	Hord Silt Loam	Lockton Loam	Hobbs Silt Loam
Irrigation	Gravity	Center Pivot	Gravity	Gravity	Center Pivot
Date 1st soil sampled	4/5	4/5	4/5	4/5	4/6
Date 2nd soil sampled	6/6	6/7	6/6	6/6	6/6
Date Preplant fert. applied	4/14	4/15	4/14	4/14	4/15
Date Sidedress fert. applied	6/9	6/9	6/9	6/9	6/9
Total Rainfall inches	7.5	8.43	8.0	7.5	7.85

Results: Due the the lack of rainfall between the early soil sample and the June soil sample no differences in residual nitrate content were found. 4 of the 5 locations did show a relatinship between N rate and yield. 1 location showed a relationship between N application and method of application.

Table #2

Location: Hamilton Co.

Soil Type: Holder Silt Loam
Irrigation type: Gravity

N-Rate (lbs/ac)	Mean Yields (bu/ac) Preplant	Preplant (40)/Sidedress	Sidedress	Mean
0	103	123	95	107
40	125	125	125	125
80	130	140	143	138
120	129	132	135	132
160	145	141	143	143
200	140	137	129	135
	129	133	128	

Source	PR > F
M	NS
R	.01
M*R	NS
C.V. = 16.7	

Total irrigation water	:13.5 inches
Nitrates in water	: 4 ppm
Early spring NO3-N lbs/6 ft	: 93
June NO3-N lbs/ 6 ft	: 103
Recommended N 150 YG	: 95 #/A

Table #3

Location: Merrick Co.

Soil Type: O-Neal Sandy Loam
Irrigation type: Center Pivot

N-Rate (lbs/ac)	Mean Yields (bu/ac) Preplant	Preplant (40)/Sidedress	Sidedress	Mean
0	144	118	125	129
40	142	145	145	144
80	177	166	166	170
120	185	187	176	183
160	182	190	184	185
200	177	182	180	180
	168	165	163	

Source	PR > F
M	NS
R	.01
M*R	NS
C.V. = 13.7	

Total irrigation water	: 18.5 inches
Nitrates in water	: 10.2 ppm
Early spring NO3-N lbs/ 6 ft	: 70
June NO3-N lbs/6 ft	: 62
Recommended N 180 YG	: 120 lbs/A

Table #4

Location: Merrick Co.		Soil Type: Hord Silt Loam Irrigation Type: Gravity Mean Yields (bu/ac)		
N-Rate (lbs/ac)	Preplant	Preplant (40)/Sidedress	Sidedress	Mean
0	107	100	116	108
40	112	116	128	119
80	134	129	156	140
120	137	141	153	144
160	162	162	172	165
200	158	170	171	166
	135	136	149	

Source	PR > F
M	.02
R	.01
M*R	NS

C.V. = 14.0

Total irrigation water	:	15 inches
Nitrates in water	:	5 ppm
Early spring NO3-N lbs/6 ft	:	54
June NO3-N lbs/6 ft	:	58
Recommended N 170 YG	:	153 lbs/A

Table #5

Location: Merrick Co.		Soil Type: Lockton Loam Irrigation Type: Gravity Mean Yields (bu/ac)		
N-Rate (lbs/ac)	Preplant	Preplant (40)/Sidedress	Sidedress	Mean
0	132	119	115	122
40	129	133	133	132
80	138	157	171	155
120	156	168	170	165
160	176	178	188	181
200	172	173	187	177
	150	155	161	

Source	PR > F
M	NS
R	.01
M*R	NS

C.V. = 10.7

Total irrigation water	:	15 inches
Nitrates in water	:	8 ppm
Early spring NO3-N lbs/6 ft	:	57
June NO3-N lbs/6 ft	:	80
Recommended N 180 YG	:	150 lbs/A

Table #6

Location: Boone Co.

Soil Type: Hobbs Silt Loam
Irrigation Type: Center Pivot

N-Rate (lbs/ac)	Preplant	Mean Yields (bu/ac) Preplant (40)/Sidedress	Sidedress	Mean
0	125	132	132	130
40	143	136	124	134
80	140	133	144	139
120	131	148	149	143
160	144	144	144	144
200	143	146	142	144
	138	140	139	

Source	PR > F
M	NS
R	NS
M*R	NS
C.V. = 18.4	

Total irrigation water	:	14 inches
Nitrates in water	:	0 ppm
Early spring NO3-N lbs/6 ft	:	148
June NO3-N lbs/6 ft	:	174
Recommended N 150 YG	:	55 lbs/A

Nitrogen Fertilization of Smooth Brome

Richard B. Ferguson

Objective: To evaluate the long-term effects of nitrogen fertilizer rate, source, and application method on the yield and nitrogen use efficiency of smooth brome.

Location: The U.S. Meat Animal Research Center, adjacent to the South Central Research and Extension Center Research Farm, Clay Center.

Procedures: This was the third year of this study. Three nitrogen fertilizer rates (50, 100, and 150 lb N/acre) were applied with three nitrogen sources (ammonium nitrate, urea and UAN solution). The UAN solution was applied by three methods (broadcast, surface-band, and knife). The ammonium nitrate and urea were broadcast. Knife and surface-band UAN treatments were applied on 15 in centers. The study site is located on a Crete silt loam soil. Fertilizer application was March 22, 1988.

Experimental results: Lack of rainfall was quite evident in forage yields from this study in 1988. Forage yields (Table 1) were 1/3 to 1/2 yield levels in 1987. Averaged across N sources, the application of N did not increase yield above the first increment of 50 lb N/acre. Knife application of UAN resulted in a reduction of yield from the surface-band (DR) and broadcast (BR) methods. This same effect was noted in 1987 at higher yield levels. These results are consistent with data from other sources which have shown significant immobilization of knifed N in roots of established sod, with accompanying yield reductions compared to broadcast or surface-banded application methods.

This study will be continued without change in 1989.

Table 1.

Comparison of nitrogen rate, sources, and application methods for smooth brome, 1988, Clay Center, NE.

Trt	N Rate Lb/A	N Source	Method	Forage Yield lb/A @ 12.5% H_2O	Forage N	Apparent N Recovery
					%	%
1	Check	---	---	1180	1.86	----
2	KN Check	---	---	761	1.47	----
3	50	AN	BR	2885	2.09	----
4	100	AN	BR	3133	2.46	----
5	150	AN	BR	1588	2.91	----
6	50	UREA	BR	2780	2.03	----
7	100	UREA	BR	3064	2.50	----
8	150	UREA	BR	2418	2.81	----
9	50	UAN	BR	2309	1.75	----
10	100	UAN	BR	2229	2.89	----
11	150	UAN	BR	2872	2.60	----
12	50	UAN	KN	1072	1.83	----
13	100	UAN	KN	1125	2.10	----
14	150	UAN	KN	1880	2.21	----
15	50	UAN	DR	2791	1.76	----
16	100	UAN	DR	2696	2.31	----
17	150	UAN	DR	3416	2.44	----
		LSD (0.05)		1086	0.66	
		F VALUE		4.63	3.35	
		C.V.		34.3	21.0	
Mean Values						
	N Rate	50		2368 a	1.89 b	53.7 a
		100		2449 a	2.45 a	41.8 ab
		150		2435 a	2.59 a	29.1 b
		PR>F		0.95	0.0001	0.0045
		C.V.		35.7	18.9	53.8
	N Source	AN		2535 a	2.47 a	52.8 a
		UREA		2754 a	2.44 a	55.3 a
		UAN-BR		2470 a	2.41 ab	43.1 a
		UAN-DR		2968 a	2.17 ab	48.2 a
		UAN-KN		1359 b	2.05 b	8.2 b
		PR>F		0.0004	0.0681	0.0001
		C.V.		35.7	18.9	53.8

Phosphorus Placement for Grain Sorghum

Richard B. Ferguson

Objective: The primary objective of this study is to evaluate the effects of different phosphorus placement methods on grain yield and P uptake by grain sorghum. A secondary objective is to determine the influence of the placement method on the spatial P concentration in the surface layer of soil.

Procedure: This was the second year of this study, in which four application methods of P fertilizer have been compared. The four application methods used were: broadcast and incorporated with a rotary tiller (BR), starter (ST), surface-banded over the row location and incorporated with a rotary tiller (BI), and knifed on both sides of the row (KN). These four methods were compared at four rates of P application (8, 16, 24, and 32 lb P/acre), (9, 18, 27, and 36 kg P/ha). These rates are equivalent to 18, 37, 55, and 74 lb P_2O_5/acre. Two sites were used in 1988 for the study. One site, located near Ohiowa in Fillmore county, was located on an eroded Hastings silty clay loam (6-11 percent slope), with an average Bray P concentration of 7 ppm. The other site was located near Bladen in Webster county, on a severely eroded Holdrege silt loam (7-10 percent slope), with an average Bray P concentration of 8 ppm.

Both fields had been previously fertilized with anhydrous ammonia prior to planting, receiving approximately 85 lb N/acre. The previous crop at the Fillmore county site was soybean, the previous crop in Webster county was grain sorghum. Fertilizer was applied and sorghum planted June 6 in Fillmore county, June 7 in Webster county. Nitrogen solution was balanced on all plots such that an additional 22 lb N/acre was applied above the N applied as anhydrous ammonia. The grain sorghum hybrid was Dekalb DK 48.

Broadcast treatments were applied uniformly across the plot, then incorporated with a rotary tiller to a depth of 3-4 in. Starter treatments were applied in one band per row, approximately 2.5 in to the side and 1.5 in below the seed. Surface-band treatments were banded directly over the row location, tilled to a depth of 3-4 in, then planted. Knife treatments were applied with two knives per row, 7.5 in on either side of the row. A rotary tiller which incorporated soil vertically was used.

Whole plant samples were taken at the Webster county site at physiological maturity for dry matter yield and P content. Grain was harvested at both locations with a two-row plot combine. Grain was analyzed from both locations for P content.

Results: Both sites of this study were affected by a lack of moisture. At the Fillmore county site, germination and emergence was erratic, resulting in uneven plant populations among plots. At the Webster county site, excellent germination and emergence occurred, resulting in too thick a population later in the season as moisture stress occurred. Consequently, grain yields were reduced at both sites (Tables 1 and 2). There was no significant effect of P rate or placement method on yield at the Fillmore county site (Table

1). Leaf P was reduced by BR application compared to the other methods. Grain P was highest with the BI and KN application methods. At the Webster county site, there was a trend towards increased grain yield with application of P (Table 2). Dry matter yield did increase significantly with P application. There were no differences in grain or dry matter yield with method of P application.

In summary, the over-riding factor affecting yield and P recovery in 1988 was climate. There were trends towards increased grain and or dry matter yield with P application, and trends towards more efficient P use with KN or BI application.

This study will be continued in 1989.

Table 1.

Comparison of P fertilizer rate and placement methods, 1988, Fillmore Co.

Trt	P Rate	Application Method	Yield	Leaf P	Grain P	Grain P Uptake
	Lb/A		Bu/A	-------- %	--------	Lb/A
1	0	--	67.3	.273	.313	11.9
2	8	BR	67.2	.240	.280	10.5
3	16	BR	63.6	.247	.308	10.9
4	24	BR	77.4	.256	.294	12.7
5	32	BR	61.0	.247	.195	7.9
6	8	KN	64.5	.293	.323	11.7
7	16	KN	67.2	.267	.318	12.0
8	24	KN	66.0	.258	.295	11.2
9	32	KN	81.9	.255	.313	14.3
10	8	ST	69.9	.255	.313	12.4
11	16	ST	61.3	.275	.238	8.7
12	24	ST	79.4	.263	.333	14.9
13	32	ST	65.2	.275	.335	12.1
14	8	BI	57.5	.275	.340	11.1
15	16	BI	71.2	.298	.313	12.5
16	24	BI	68.2	.265	.300	11.5
17	32	BI	40.4	.288	.343	7.6
		PR>F	0.123	0.146	0.199	0.262
		LSD (0.05)	21.7	0.040	0.090	4.9
		C.V.	23.1	10.8	21.2	30.3

Mean Values

		Yield	Leaf P	Grain P
P Rate	8	66.6ab	.272a	.317a
	16	64.0ab	.264a	.292a
	24	74.0a	.260a	.307a
	32	61.4b	.265a	.290a
	PR>F	0.104	0.669	0.588
	C.V.	22.5	11.3	20.0
Method	BR	68.0a	.243b	.264b
	ST	67.2a	.271a	.306ab
	KN	69.4a	.266a	.311a
	BI	61.6a	.281a	.323a
	PR>F	0.497	0.012	0.065
	C.V.	22.5	11.3	20.0

Table 2.

Comparison of P fertilizer rates and placement methods, 1988, Webster Co.

Trt	P Rate	Application Method	Yield	Dry Matter	P Concentration Leaf	Grain	Stover	P Uptake Grain	Stover
	Lb/A		Bu/A	Lb/A	---------- %		--------	---- Lb/A	----
1	0	---	50.7	8104	.328	.305	.185	8.7	22.9
2	8	BR	59.3	9902	.320	.278	.133	9.4	20.1
3	16	BR	62.9	9017	.313	.288	.165	10.1	24.9
4	24	BR	58.1	11184	.280	.283	.120	9.4	22.8
5	32	BR	56.1	9962	.273	.255	.135	8.0	21.6
6	8	KN	55.3	10710	.268	.300	.138	9.1	23.7
7	16	KN	65.4	9890	.285	.273	.133	9.8	23.0
8	24	KN	51.8	9008	.290	.278	.160	8.1	22.5
9	32	KN	57.2	8375	.290	.285	.148	9.1	21.2
10	8	ST	59.2	10179	.280	.308	.117	10.2	22.2
11	16	ST	56.7	10184	.298	.313	.130	9.9	23.1
12	24	ST	60.1	9599	.293	.333	.163	11.2	27.0
13	32	ST	59.0	9292	.295	.300	.163	9.9	24.8
14	8	BI	55.3	8177	.278	.293	.168	9.2	23.0
15	16	BI	55.3	9910	.285	.318	.145	9.9	24.5
16	24	BI	59.8	8539	.278	.305	.128	10.4	21.1
17	32	BI	62.0	10050	.288	.330	.143	11.5	25.7
		PR>F	0.888	0.374	0.652	0.602	0.196	0.488	0.940
		LSD (0.05)	NS	2398	NS	NS	0.050	2.70	NS
		C.V.	17.2	17.9	12.4	27.9	11.9	19.8	21.7

Mean Values

		Yield	Dry Matter	Leaf	Grain	Stover
P Rate	8	54.4a	8908b	.289ab	.298a	.135a
	16	58.8a	9267ab	.299a	.305a	.157a
	24	58.7a	9618ab	.283b	.283a	.145a
	32	61.4a	10474a	.280b	.296a	.134a
	PR>F	0.277	0.059	0.531	.0215	0.053
	C.V.	17.2	6.7	12.0	23.6	16.6
Method	BR	60.6a	9754a	.297a	.278c	.143a
	ST	57.8a	9341a	.294ab	.312a	.146a
	KN	58.2a	9609a	.281b	.284bc	.139a
	BI	58.9a	9566a	.280b	.308ab	.143a
	PR>F	0.610	0.037	0.041	0.952	0.860
	C.V.	17.2	6.7	12.0	23.6	16.6

Residual Effects of Treatments Applied to the
Soil Test Lab Comparison Study

Gary W. Hergert and Charles A. Shapiro

OBJECTIVES:

1. The overall objective of the soil test lab comparison experiments was to promote uniform fertilizer recommendations among laboratories.

2. The second objective was to determine if university fertilizer recommendations were adequate to produce optimum economic yields.

This study was discontinued in 1985. A completion report and summary through the 1984 is available as Agronomy Department Report No. 49.

PROCEDURES: Since 1986 plots at North Platte, Concord, and Mead have been continued as a residual study. Only nitrogen has been applied to the plots based on yield goal or yield goal and residual nitrate nitrogen. Soil samples have been taken to reflect changes in soil test values over time.

RESULTS:

North Platte

Soil test lab results of particular interest at this location are residual nitrate, phosphorus and zinc. After 1985 nitrogen applications were made based on residual nitrate soil tests. Nitrogen application rates for the three years are given in Table 1. Previous N fertilization had provided a wide range of residual nitrate levels. The use of the adjusted nitrogen rates in 1986 produced an amazingly similar residual nitrate carryover shown by the spring 1987 data. The yields all three years were exceptional (Table 2). A nitrogen rate study using nitrogen rates of 0, 100, 200, and 300 pounds N/A is also included with the soil test lab study at North Platte and these plots have also been continued. The yields of the higher nitrogen rates on those plots during 1986 through 1988 produced no higher maximum yield than the lab comparison plots indicating the nitrogen rates were adequate.

Following years of phosphorus and zinc applications there were substantial differences in the soil test levels of phosphorus and zinc between the laboratories. This is shown in the 1986 data when all samples were run by the UNL lab (Table 1). Over time the P soil test levels have declined. The UNL plot is approaching the current suggested critical level of 15 ppm phosphorus. However, this plot produced excellent yields that were equal to those of the other plots which had higher residual phosphorus levels during 1986 through 1988. These data confirm the UNL philosophy of recommending immobile nutrients such as phosphorus on a deficiency correction basis rather than a soil maintenance and build.

Table 1. Soil test level at North Platte.

	Bray-1 P				DTPA Zn				NO_3-N			N applied		
LAB	85	86	87	88	85	86	87	88	86	87	88	86	87	88
	ppm								-lbs/A-6 ft-					
A	39	39	--	25	2.8	1.5	-	1.4	140	99	60	100	180	180
B	37	37	29	29	2.6	2.7	6.9*	2.2	308	103	56	0	180	180
C	54	28	22	21	2.6	3.1	14.2*	3.9	187	99	53	50	180	180
D	52	35	23	23	-	1.3	4.6*	1.1	196	98	68	40	180	180
E**	29	19	--	16	13.0*	1.7	-	1.9	146	96	60	100	180	180

*HCL Index Hi
**UNL Laboratory

Table 2. Grain yield at North Platte.

LAB	1985	1986	1987	1988	X 86-88
	bu/A				
A	187 a*	213 a	218 a	224 a	218 a
B	190 a	206 a	220 a	222 a	216 a
C	192 a	201 a	222 a	212 a	212 a
D	193 a	204 a	219 a	209 a	210 a
E	188 a	200 a	223 a	219 a	214 a
CV	7.0%	7.1%	4.2%	4.6%	

*Values followed by the same letter are not significantly different at the 5% level.

Concord

Plots at Concord were soil sampled in 1987 and 1988 (Table 3). Two of the labs (C and E) have phosphorus levels below 15. However, no phosphorus was applied from 1986 through 1988. Even though the phosphorus level was low it did not influence yields for the period 1986 through 1988 (Table 4). The zinc level in 1987 was adequate for all plots as was the potassium level. Since this is a nonirrigated location variations in yield are do primarily to differences in seasonal rainfall rather than soil fertility level. The data from this location and North Platte indicate that the 15 ppm cutoff level for soil phosphorus is adequate for most Nebraska soils to produce excellent corn yields under irrigated or dryland conditions.

Table 3. Soil test levels at Concord.

LAB	Bray-1 P			Zn index	K	
	86	87	88	87	87	88
	ppm					
A	22	19	16	5.9	250	247
B	21	16	15	5.9	224	252
C	12	11	11	6.4	227	246
D	23	19	17	6.3	225	225
E (UNL)	13	13	11	6.5	228	246

Table 4. Grain yield at Concord.

LAB	1985	1986	1987	1988
	bu/A			
A	104 a*	92**	95 a	55 a
B	103 a	130	98 a	54 a
C	97 a	99	98 a	58 a
D	101 a	127	88 a	54 a
E	100 a	114	101 a	53 a
CV	8.6%	-	10.7%	24.0%

*Values followed by the same letter are not significantly different at the 5% level.
**Statistics not run.

1988 Progress Report on the B-K-R Demonstration Farm

Gary W. Hergert, Dennis Bauer, and Don Sander

I. Liming Study

Objectives:

1. To evaluate the effect of various lime sources and rates on the soil and crop yields in a corn-soybean rotation on an acid sandy soil.
2. To demonstrate the economics of liming with various lime sources.

Procedure:

The liming experiment was established in 1985 on a Valentine Boelus fine sand. Soil analysis in the spring of 1985 showed a pH of 5.6, 1% Organic Matter, 34 ppm Bray 1P, 138 ppm K, and 0.8 ppm sulfur. The liming recommendation was 1,000 pounds of ag lime/acre. Four treatments including a check, broadcast and incorporated ag lime, broadcast and incorporated pelleted lime, and row applied pelleted lime were used. The broadcast pelleted lime rate was selected by spending the same dollar amount as was spent for the ag lime. Ag lime was broadcast April 18 and incorporated by a single disking. Treatments were laid out in replicated strips which ranged in width from 20 to 50 feet wide the length of the pivot. Four replications were used.

No difference in soil pH for the various treatments was shown in 1986 and based on the soil tests from the limed plot an additional 3000 pounds of ag lime was recommended (Table 1). In 1986 the ag lime plot from 1985 was split. Half received no additional lime while the other half received the 3000 pounds of ag lime. The broadcast pelleted lime treatment was also split. Half did not receive any additional lime and the other half received a broadcast application of 1250 pounds of pelleted lime per acre. The liming rates in both 1985 and 1986 for the pelleted lime were based on spending the same amount of money for ag lime. All broadcast lime treatments were incorporated by single disking. Soybeans were planted in 1986.

Results:

In 1987 no additional treatments were applied and corn was planted following the soybeans. The pH values of the various treatments over time show an interesting effect (Fig. 1). Following the year of corn in 1985 the soil pH levels in 1986 had declined by about half a pH unit. In 1987 following the year of soybeans the pH had increased to its initial level. In 1988 pH levels had declined again following corn. The reason for this change in pH is the lime that is applied in the irrigation water during the growing season and the lack of nitrogen fertilizer. During years following corn production the pH is expected to drop because of the use of nitrogen fertilizer.

Table 1. pH values in the 0-8 inch depth before planting.

	1985 Corn	1986 Soybean	1987 Corn	1988 Soybean
Check	5.6 a*	5.1 a	5.5 b	4.8 ab
Ag Lime - 85	5.6 a	5.1 a	5.5 b	4.9 ab
Ag Lime - 85 & 86	5.6 a	5.1 a	5.7 a	5.0 a
Pelleted - 85	5.6 a	5.1 a	-	5.0 ab
Pelleted - 85 & 86	5.6 a	5.1 a	5.6 a	5.0 ab
Row-applied	5.6 a	5.0 a	-	4.7 b

*Values followed by the same letter are not significantly different at the 10% level of probability.

There was a significant but inconsistent liming effect on soybean yield in 1986 and 1988 (Table 2). The highest rate of lime produced a significantly better soybean yield than the check. Other treatments were intermediate. During both 1985 and 1987 no significant lime effect was shown for corn. Yields were lower in 1985 due to a mid-season hail storm. In 1987 the poor performance of the row applied lime cannot be explained. Stand counts were not taken, however, the application of the pelleted lime with the seed for corn reduced the stand and the yield potential. This treatment did yield significantly less than the other treatments.

Table 2. Yields for the B-K-R corn-soybean rotation liming experiment.

	Corn 1985	Soybeans 1986	Corn 1987	Soybeans 1988
	bu/A			
Check	115 a*	45.9 b	154 ab	50.2 ab
Ag Lime - 85	118 a	47.7 ab	158 a	54.8 a
Ag Lime - 85 & 86	---	51.4 a	154 ab	48.4 b
Pelleted - 85	114 a	46.1 b	151 ab	45.9 b
Pelleted - 85 & 86	---	45.4 b	152 ab	48.2 b
Row-applied	117 a	47.6 ab	142 b	-
CV	4%	6%	7%	8%

*Values followed by the same letter are not significantly different at the 10% level of probability.

In 1987 and 1988 the plots were sampled at increments of 0-4, 4-8, and 8-16" (Table 3). The influence of lime is more evident in the 0-4" depth (Fig. 2). Also note lower pH in the 4-8" depth due to N application. The 1987 data showed the influence of liming even at the 8-16" depth.

Table 3. Soil pH for 0-4, 4-8, and 8-16" samples.

	1987 - Corn			1988 - Soybeans		
	0-4	4-8	8-16	0-4	4-8	8-16
Check	5.7 c	5.3 a	5.6 c	5.0 bc	4.6 a	5.0 a
Ag Lime 85	6.0 b	5.3 a	5.9 a	5.1 bc	4.7 a	5.1 a
Ag Lime 85 & 86	6.5 a	5.5 a	5.9 a	5.6 a	4.8 a	5.0 a
Pelleted 85	-	-	-	5.2 a	4.8 a	5.1 a
Pelleted 85 & 86	6.1 b	5.4 a	5.7 b	5.3 b	4.8 a	5.1 a
Row 85-87	-	-	-	4.9 c	4.6 a	4.9 a

Based on previous work liming on sandy soils may not be beneficial for corn until soil pH levels decline to less than pH 5.2. Liming did increase soybean yields in 1986. If the payback in a corn-soybean rotation is sufficient over a 5 to 8 year period liming can be recommended.

II. Soil Test Lab Comparison Experiment

Objectives:

1. Determine if soil test lab recommendations varied widely on an infertile sandy soil.
2. Determine if UNL recommendations are adequate to produce economic yields on sandy soils.

A soil test lab comparison study conducted by the University of Nebraska for a number of years showed a wide range in fertilizer recommendations between a number of laboratories. These experiments did confirm the accuracy of the laboratories' analytical techniques. However, there was a wide variation in the recommendations. Most of these experiments were conducted on silt loam soils that were high to medium fertility.

The University has a major responsibility to provide research information upon which fertilizer recommendations are made to commercial soil testing labs. These experiments provide a check on the University recommendations. This experiment was originated to enhance the value of soil testing which eventually benefits the entire agricultural community. It is fully expected that commercial soil testing laboratories will continue to handle a major portion of the soil testing business as the University Lab only tests about 5% of the soil samples in the state at this time.

Procedure:

A composite soil sample was taken out of the four replications for a given laboratory and sent to that laboratory under a farmer's name. The four laboratories selected were A&L Laboratories, Harris, Servi-Tech, and UNL. The actual soil test results are shown in Table 4. There was fairly good agreement between the different soil test levels and the analysis did show that the site was low in most nutrient levels. The biggest variation in analytical values for sulfur because of lab methodology.

Table 4a. Soil test results for the B-K-R soil tst lab comparison, 1987.

Laboratory	pH	O.M.	P	K	Zn	S
			---------------	ppm	---------------	
A&L	5.9	1.8%	7	98	0.8	9
Harris	6.0	1.7%	4	107	0.8	2
Servi-Tech	6.2	1.7%	5	146	0.8	6
UNL	6.0	1.5%	5	125	2.7*	1

*HCl Test

Table 4b. Soil test results for the B-K-R soil tst lab comparison, 1988.

Lavoratory	pH	O.M.	P	K	Zn	S	Mg	Mn	Cu	B
			-----------	-----------	-----------	ppm	-----------	-----------	-----------	-----------
A&L	5.8	1.3%	4	103	1.6	11	76	5.0	.4	.7
Harris	6.1	1.4%	11	118	2.1	3	81	4.4	.4	.5
Servi-Tech	5.7	1.5	13	138	1.4	10	79	5.6	-	-
UNL	6.6	1.5	8	123	5.4*	3	--	-	-	-

*HCl Test

Laboratories were provided with information on soil type, suggesting a yield goal of 165 bushel corn. The actual fertilizer recommended by the different laboratories is shown in Table 5. Corn variety Horizon 4112 was planted April 30, 1987 and harvested October 13. Pioneer 3475 was planted April 29, 1988 and harvested mid-October. To provide for the best nitrogen management between laboratories all of the nutrients plus 40 pounds of nitrogen was applied preplant in 1987 to each of the plots. The remaining amount of nitrogen was applied as a sidedress application of ammonium nitrate when the corn was approximately 2 feet tall. This method of fertilizer application allowed incorporation of broadcast phosphorus, sulfur, zinc, and other micronutrients or secondary nutrients. It also provided a split application for the nitrogen to best utilize the nitrogen that was recommended by the laboratories.

Table 5a. Fertilizer recommended for 165 bushel corn in 1987.

Laboratory	N	P	K	S	Fertilizer Bill-NPKS
	--------------lbs/A-----------				
A&L	220	110	140	25	$87.00
Harris	195	135	125	35	$90.30
Servi-Tech	165	95	25	15	$57.60
UNL	170	100	40	20	$62.70

	Mg	Zn	B	Cu	Mn	Total Bill
	-------------------lbs/A-----------------					
A&L	22	5	1.0	1.5	3.5	$109.11
Harris	20	10	1.5	2.3	5.5	$121.10
Servi-Tech	0	3	0.5	0	0	$ 61.65
UNL	0	3	0	0	0	$ 65.40

Table 5b. Fertilizer recommended for 165 bushel corn in 1988.

Laboratory	N	P	K	S	Fertilizer Bill-NPKS
	--------------lbs/A-----------				
A&L	210	115	140	14	$84.70
Harris	195	95	110	35	$77.15
Servi-Tech	210	65	30	0	$53.60
UNL	170	40	40	20	$45.60

	Mg	Zn	B	Cu	Mn	Total Bill
	-------------------lbs/A-----------------					
A&L	30	3	1.0	1.0	3.0	$106.40
Harris	20	0	1.25	0.5	2.0	$ 90.98
Servi-Tech	0	0	0	0	0	$ 53.60
UNL	0	0	0	0	0	$ 45.60

Fertilizer cost per pound used were N - $0.15, P - $0.28, K - $0.13, Mg - $0.38, S - $0.20, Zn - $0.90, Mn - $0.80, Cu - $02.50, and B - $2.70. The total cost ranged from $61.65 to $121.10 in 1987 and $45.60 to $106.40 in 1988 (Table 5). The yield attained in 1987 (183 bu/A) were excellent and exceeded the yield goal (165 bu/A) (Table 6).

Table 6. Corn yields for the BKR soil lab comparison experiment.

Laboratory	1987 bu/A #2	1987 % Moisture	1988 bu/A #2	1988 % Moisture
A&L	182 a*	12.9 a	144 a	17.1 a
Harris	180 a	13.3 a	137 bc	17.0 a
Servi-Tech	184 a	12.8 a	139 b	16.7 a
UNL	186 a	12.9 a	133 c	17.2 a

*Values followed by a different letter are significantly different at the 10% level.

In 1988 there was a significant yield difference. The 40# of preplant N was applied but 40# of N was also applied with the herbicide. Because of heavy early spring rains leaching occurred. The 90# N left for sidedressing university plots was not sufficient to meet yield demands. The data does emphasize the importance of proper N management and that soluble forms of N can be lost. No more than 40# of N/A as a preplant is recommended for sandy soils when dry or liquid N is used.

The results from this two year study are not different than those attained over the 15 year history of soil test lab comparison experiments previously conducted by UNL. The information shows that the laboratories are doing a good job of providing analytical results although differences in recommendations remain. Two laboratories (UNL and Servi-Tech) are recommending on a deficiency correction basis and both produced very good yields. The results confirm that the deficiency correction approach does not limit yields or benefits if the yield attained is above the specified yield goal. If this were not true, the higher N, P, K, and S rates would or should have produced a higher yield. The Servi-Tech Laboratory produced the yield at a similar cost to UNL. The other two laboratories' costs were increased by larger additions of nitrogen, potassium, sulfur, micronutrients and secondary nutrients. Past research on Nebraska soils show that many of these nutrients often do not provide economic yield increases.

III. Phosphorus Rate and Method Experiment

Objectives:

1. Compare the response of corn to broadcast, incorporated, row-applied and deep-banded P from 10-34-0.
2. Determine the effect of different initial soil P levels on the response of the three methods.

Phosphorus was applied to 80' by 80' blocks in the spring of 1986. The phosphate rates applied were 0, 40, or 80 lbs/P_2O_5/A. A corn crop was grown on this area in 1986. In the spring of 1987 soil samples were taken from this area and showed that the check area had a soil test level of about 5 ppm P, the area fertilized with 40 pounds of phosphate had a soil test level of about 9 ppm and the area receiving 80 had a soil test level of 13 ppm P. A phosphorus rate by method experiment was designed for this area and fertilizer was applied in the spring of 1987 and 1988. The phosphorus application methods used included broadcast, deep banded or knifed in and row application at planting time. 10-34-0 was the phosphorus fertilizer used for each method. Nitrogen rates were balanced by inclusion of nitrogen solution so nitrogen was balanced between all treatments. Phosphorus rates were 0, 15, 30, 45, 60, and 75 pounds of phosphate/A.

The results (Table 7) showed no difference in response based on initial soil test P level, consequently data have been averaged to show the effects of application method and P rate. In 1987 row-applied P was significantly better than broadcast or deep banded P (Fig. 3). In 1988 there was no difference among methods. Due to lack of consistent method differences, more sites will need to be run to recommend one method over another.

Table 7. Grain yield for the B-K-R P rate x method experiment, 1987 and 1988.

	Initial Soil P Application in 1986					
	1987		1988			
	------------bu/A------------					
METHOD						
Broadcast	149		147			
Deep Band	148		148			
Row	155		147			
	1987			1988		
RATE-lbs/A	Bcst	DP Band	Row	Bcst	DP Band	Row
0	133	133	133	125	125	125
15	135	136	143	136	134	136
30	140	142	151	144	147	141
45	153	146	159	147	150	147
60	157	152	161	150	152	154
75	160	164	163	157	158	158

Fig. 1

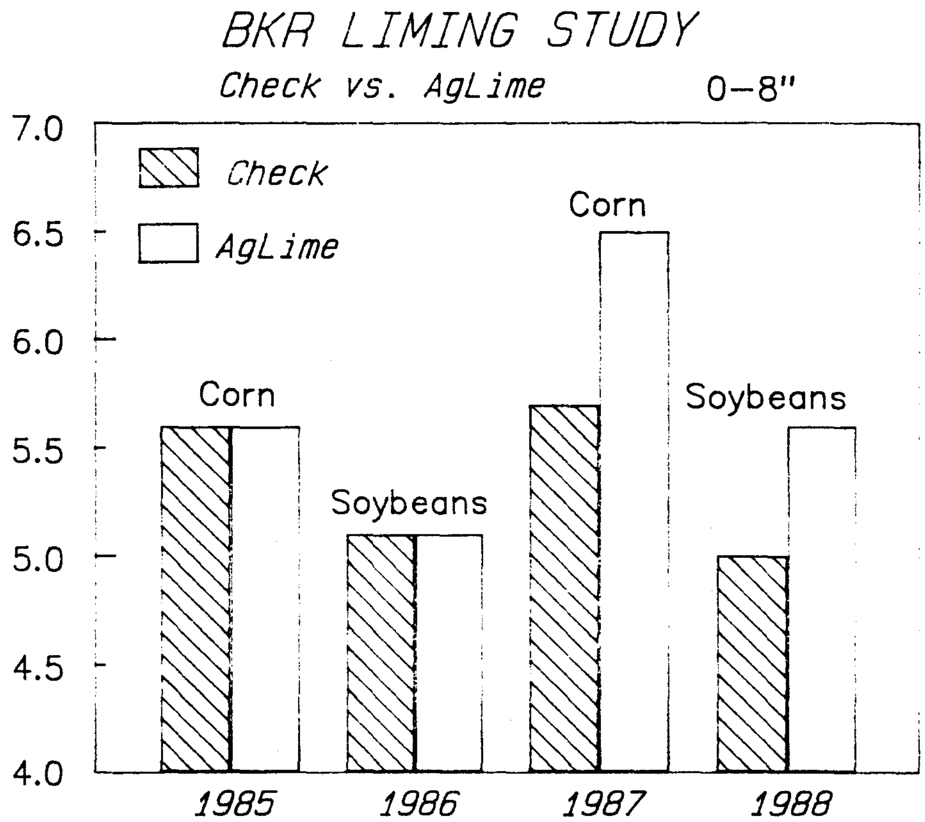
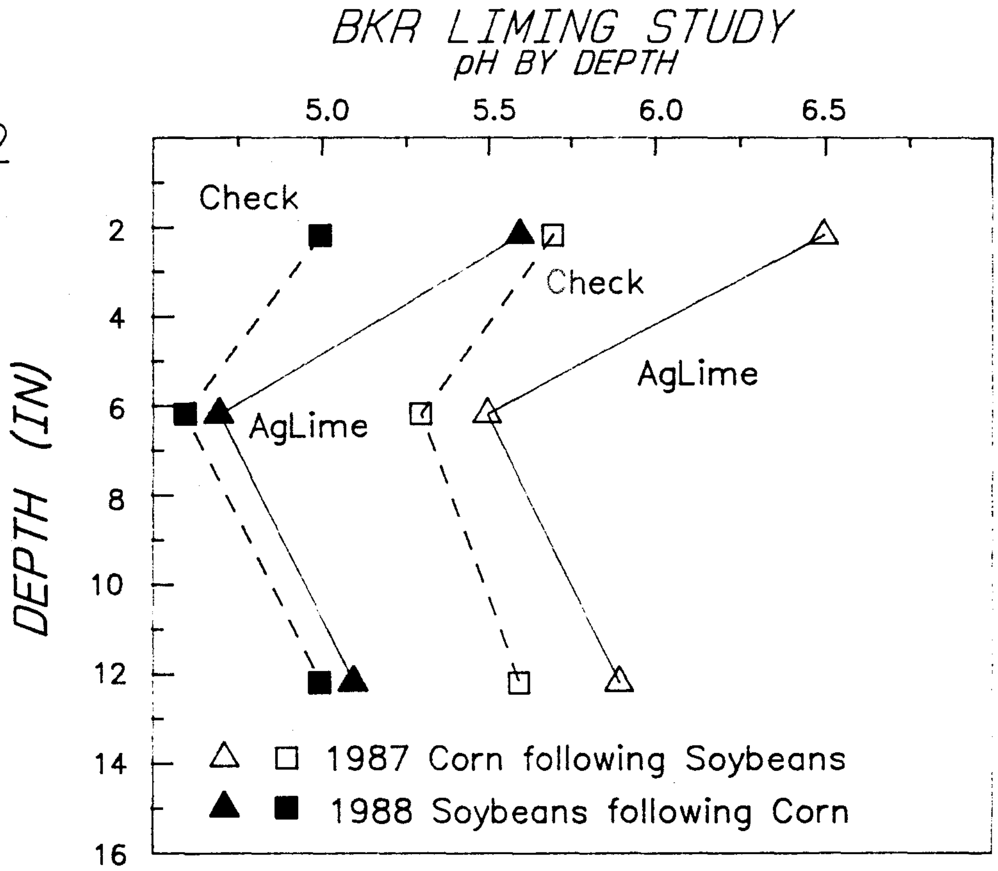
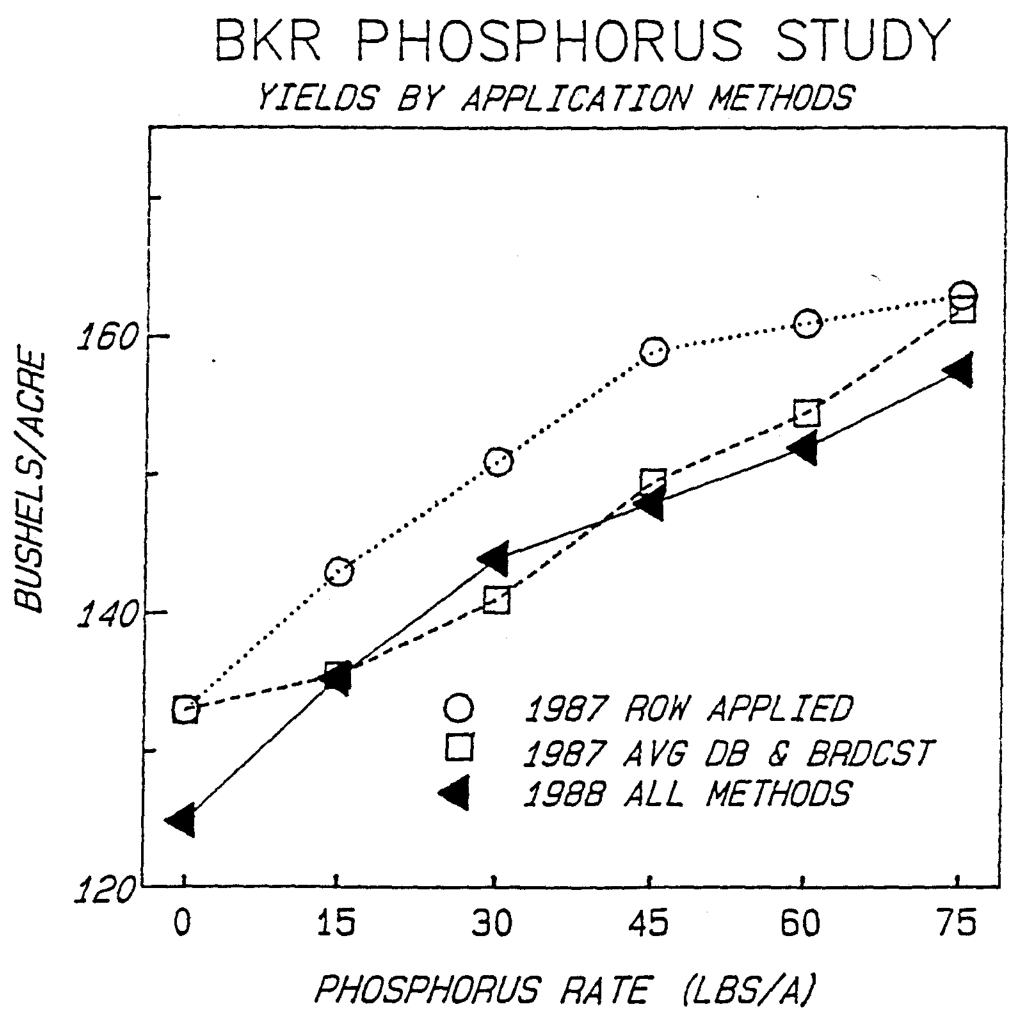

BKR LIMING STUDY
Check vs. AgLime
0-8"
7.0
6.5
6.0
5.5
5.0
4.5
4.0
Check
AgLime
Corn
Soybeans
Corn
Soybeans
1985
1986
1987
1988

Fig. 2


BKR LIMING STUDY
pH BY DEPTH
5.0
5.5
6.0
6.5
DEPTH (IN)
2
4
6
8
10
12
14
16
Check
Check
AgLime
AgLime
1987 Corn following Soybeans
1988 Soybeans following Corn


BKR PHOSPHORUS STUDY
YIELDS BY APPLICATION METHODS
BUSHELS/ACRE
160
140
120
0
15
30
45
60
75
PHOSPHORUS RATE (LBS/A)
1987 ROW APPLIED
1987 AVG DB & BRDCST
1988 ALL METHODS

DYNAMICS OF WATER IN RIGID AND SWELLING SOILS

D. Swartzendruber

Objective:

The general objective of this report is to analyze and quantify the processes by which water flows into and through porous media and soils under both saturated and unsaturated conditions. Swelling and nonswelling soils are considered.

Procedure:

As far as reasonably possible, each flow process is approached as a mathematical boundary-value problem to be solved by classical mathematical means or by computer if necessary. Experiments are conducted in the laboratory with vertical flow columns on which measurements of water content and soil bulk density are obtained by the attenuation of dual-energy gamma radiation. Other flow measurements are taken as needed.

Results and Discussion:

Extensive analysis of laboratory data, for water absorption into upward-swelling columns of an equal-part mixture of Wyoming bentonite and quartz silt, has now been completed. Volumetric water content and bulk density of the porous medium had been measured nondestructively within the column over a period of 1 to 2 weeks, by the attenuation of a narrowly collimated beam of dual-energy gamma rays. Theoretically, it was found necessary to consider the porous-medium void ratio to be a function of both fractional water saturation (volume of water per unit pore volume) and time. This introduced an auxiliary time dependence into the water diffusivity function. Also, to allow for an experimentally feasible boundary condition, the governing differential flow equation was recast in terms of the fractional water saturation. A mathematical solution of the flow problem was sought and found in terms of product-form separation of variables. Some early-time departure from square-root-of-time dependence was found for fractional water saturation as a function of the so-called material Boltzmann variable. Measurements within the porous-medium column were employed in the mathematical solution to predict the cumulative water absorption and the upward rise of the top end of the swelling column.

For possible use in resource management models, the Green and Ampt infiltration-equation parameters--wetting-front suction head S and near-saturated hydraulic conductivity K--were examined for relationship between S and K. Analysis of nonsimilar-media scaling and a capillary-tube bundle implied a relationship of power-function form. Regression analysis of extensive field data, however, showed that S envisaged as a power function of K displayed more independence than dependence.

HIGH YIELD CORN-SOYBEAN-WHEAT ROTATION STUDY

W.R. Peterson, D.T. Walters, and R.A. Olson

Objectives:

1. To compare the response of irrigated corn grown in a corn-soybean-wheat rotation to corn grown continuously over a range of fertilizer inputs with respect to yield and energy use efficiency.

2. To compare the economic returns of irrigated rotation corn versus continuous corn and the effect of projected increases in energy costs.

Procedure: Plots were established in 1981-1982 using a corn-soybean-wheat rotation and continuous corn. Design was such that every crop is produced ever year. Nine fertilizer treatments were applied including a check, 3 rates of N fertilizer, two rates of P and K, and treatments including manure and S, Zn, Cu, and B. Return over variable costs (ROVC) was calculated using the CROPBUDGET program available on AGNET.

Results: The growing season was characterized by hot, dry weather early in the growing season. Irrigation was started in early June with only moderate rainfall occurring the remainder of the season. Fifteen inches of irrigation water was applied to corn and 10.5 inches was applied to soybeans. In spite of the adverse weather corn yields were good and soybean yields were about average. The dry weather early appeared to reduce yields slightly.

Yields for 1988 are presented in Table 1. Corn grown in rotation had a very significant yield advantage over continuous corn with the top yielding rotation corn treatment yielding 69 bushels more per acre than the best yielding continuous corn treatment. The check treatment for the rotation corn outyielded all continuous corn treatments.

Soybeans did not respond to added fertilizer in 1988 (Table 1). An especially dry August appeared to reduce soybean yields more than corn yields. Wheat yields in 1988 responded to an application of phosphorus. As in past years, the manure treatment was the highest yielding treatment.

Mean yields for the four year period 1985-1988 are presented in Table 2. During the four year period, corn yield was not influenced by additions of phosphorus or potassium fertilizer, micronutrients did increase yield of continuous corn but not rotation corn. There was minimal yield response to added fertilizers for soybeans. Wheat

Table 1. Grain yields in high yield rotation experiment, 1988. Mead field lab on Sharpsburg sicl.

Treatment[1] lb/acre	Mean grain yields[2] bu/acre Cont. Corn	Rot. Corn	Soybeans	Wheat
1. Control	66 e	152 d	41a	27 c
2. 20 ton manure[3]	130 bc	188abc	43a	45a
3. 80-0-0	117 d	169 cd	38a	29abc
4. 160-0-0	128 bc	171 bcd	38a	25 c
5. 160-40-0	126 cd	196abc	40a	38abc
6. 160-40-40	125 cd	199a	42a	37abc
7. 160-40-40+20S+10Zn+1B+.5Cu	138ab	197ab	41a	44ab
8. 320-80-80	133abc	202a	43a	38abc
9. 160-40-40+20ton manure[3]	141a	168 cd	43a	41abc

1 Wheat receives 1/2 the N rate of corn, soybeans 1/4.
2 Means followed by the same letter within a column are not significantly different at the 5% level.
3 20 ton manure applied in alternate years.

Table 2. Mean yield of corn, soybeans, and wheat grown in rotation and continuous corn (1985-1988).

Treatment	Cont Corn (bu/acre)	Rot Corn	Soybeans	Wheat
1. Check	73.4 d	145.6 c	47.0 b	30.4 c
2. Manure	136.7 c	179.4 b	50.1ab	47.8a
3. 80-0-0	134.4 c	174.0 b	49.7ab	31.5 c
4. 160-0-0	151.4 b	181.6ab	49.6ab	30.5 c
5. 160-40-0	150.2 b	184.6ab	48.6ab	43.4ab
6. 160-40-40	150.8 b	187.7ab	48.2ab	39.2 b
7. 160-40-40+Micro	164.2a	183.2ab	50.8ab	42.5ab
8. 320-80-80	149.0 b	197.0a	53.2a	40.7 b
9. 160-40-40+Manure	158.6ab	173.3 b	53.3a	43.2ab
Average Yield	141.0	178.5	50.1	38.8

Means followed by same letter within columns are not significantly different at Duncan's alpha=.05.

ANOVA for Continuous corn vs Rotation corn

	df	PR>F
Year	3	.0001
Crop	1	.0001
Year*crop	3	.0001
Treatment	8	.0001
Year*treatment	24	.3269
Crop*treatment	1	.0001

yield response appeared to be related to phosphorus applications, nitrogen application without phosphorus did not increase yields.

High rates of fertilizer N were not fully utilized by corn. Significant amounts of residual nitrate-nitrogen remained in the soil profile in corn plots receiving 320 lbs/acre of N (Table 4). Check plots for corn, wheat, and soybeans all had approximately the same amount of residual NO_3^--N indicating that the crops did not differ greatly in their ability to reduce residual N to a low level when no fertilizer N was applied.

The ROVC for continuous corn, rotation corn, soybeans, and wheat by treatment is presented in Figure 1. Rotation corn had the highest returns with continuous corn and soybeans being about equal in terms of returns. Wheat was the least profitable of the four crops. When a corn-soybean-wheat ration is examined, wheat is the least profitable crop in the rotation which reduces the profitability of the rotation when compared to continuous corn.

Increasing energy costs have a major impact upon the profitability of agriculture. The influence of rising energy costs on ROVC for continuous corn and a corn-soybean-wheat rotation is presented in Figure 2. Included in the energy costs are all diesel fuel costs including diesel fuel for irrigation, propane costs for grain drying, and energy costs associated with the production of nitrogen fertilizer. As energy costs go up continuous corn is more affected than is the rotation, this is a result of corn production being more energy input intensive.

The ratio of energy input into producing corn, soybeans, wheat and a corn-soybean-wheat rotation to the grain energy produced for selected treatments by crop is presented in Table 5, this is referred to as the Energy Efficiency Ratio (EER). Treatments 1 and 4 were chosen for corn, treatment 1 for soybeans, and treatments 1 and 5 for wheat because they either provided a baseline for comparison, had the highest ROVC for the crop or both. Rotation corn had a higher EER than did continuous corn, this was due to the greater yield of the rotation corn. The check treatment for the rotation corn had a high EER reflecting the high yield for the check treatment. The continuous corn check was so nitrogen deficient that the corn plant was unable to operate efficiently. Soybeans were about equal to continuous corn in terms of EER. The check treatment had the highest EER due to soybeans lack of yield response to added fertilizer amendments. Wheat had a very high EER for the check treatment but this was due to the very low energy input requirement for producing wheat.

Table 3. Mean grain protein content (percent) for continuous corn and corn, soybeans, and wheat grown in rotation (1985-1988 wheat) (1985,1987,1988 corn and soybeans).

Treatment	% Protein			
	Cont corn	Rot Corn	Soybeans	Wheat
1. Check	7.4 c	7.6 d	39.4a	13.2 c
2. Manure	7.6 bc	8.0 c	39.2a	13.8 c
3. 80-0-0	7.7 bc	8.0 c	39.2a	14.1 bc
4. 160-0-0	8.1a	8.0 bc	40.1a	14.6ab
5. 160-40-0	7.9ab	8.3abc	40.0a	14.3 bc
6. 160-40-40	8.0ab	8.4ab	39.1a	14.4abc
7. 160-40-40+Micro	8.1a	8.3abc	39.3a	14.2 bc
8. 320-80-80	8.2a	8.4a	39.8a	14.9a
9. 160-40-40+Manure	8.1	8.5a	39.6a	14.3 bc

Means followed by the same letter within columns are not significantly different at Duncan's alpha=.05.

ANOVA Continuous corn vs Rotation corn

	df	PR>F
Year	2	.0001
Crop	1	.487
Year*crop	2	.0001
Treatment	8	.001
Year*treatment	16	.04
Crop*treatment	8	.298

Table 4. Residual nitrate-nitrogen remaining in the surface 5 feet of soil (4 feet, 1985) following continuous corn, corn grown in rotation, soybeans, and wheat crops.

Crop	Treatment	N-rate lbs/acre	Year 1985	1986	1987	1988
			lbs/acre NO_3^--N			
Cont corn	1	0	48	54	56	30
	9	320	92	91	178	288
Rotation corn	1	0	55	42	82	51
	9	320	207	102	341	492
Soybeans	1	0	61	39	52	71
Wheat	1	0	73	46	50	102

Figure 1. Mean ROVC of corn, soybeans, and wheat grown in rotation and continuous corn as affected by fertility treatment (1985-1988).

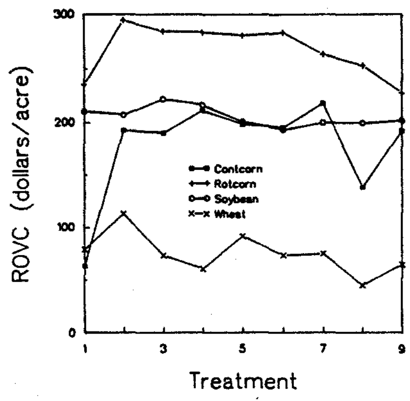
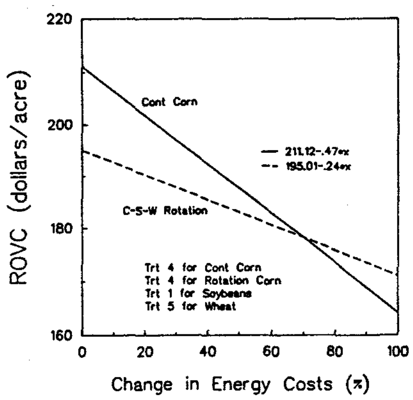


Figure 2. ROVC of a corn-soybean-wheat rotation and continuous corn as affected by increasing energy costs related to diesel fuel for field operations and irrigation, propane for grain drying, and fertilizer nitrogen.



Irrigation, grain drying, and energy associated with nitrogen fertilizer were the biggest energy expenditure items in corn production representing 28%, 8%, and 32% of the total energy expenditure respectively. Field operations represented only 10% of the total energy use for corn. Irrigation was the largest source of energy expenditure for soybeans accounting for 44% of the total. Nitrogen fertilizer for wheat represented 68% of the total energy expenditure for wheat production.

Table 5. Mean energy inputs, output and efficiency of energy use for rotation corn, continuous corn soybeans, wheat and corn-soybean-wheat rotation for selected treatments (1985-1988).

	----Cont Corn---		----Rot Corn----		Soybeans	-----Wheat-----		Rotation
	-----Mcal/acre-----							
Operation	Check	160-0-0	Check	160-0-0	Check	Check	80-40-0	Trt 4,1,5
Stalk Shredding	35.3	35.3	35.3	35.3	0	0	0	11.8
Tillage	50.4	50.4	50.4	50.4	50.4	25.2	25.2	42.0
Planting	33.9	33.9	33.9	33.9	33.9	29.5	29.5	32.4
Cultivation	63.4	63.4	63.4	63.4	63.2	0	0	42.2
Harvest	67.7	67.7	67.7	67.7	59.8	43.2	43.2	56.9
Truck	62.0	62.0	62.0	62.0	35.3	18.0	18.0	38.4
Auger	11.5	11.5	11.5	11.5	5.0	4.3	4.3	7.0
Transport	20.0	20.0	20.0	20.0	15.5	20.1	20.1	18.5
Seed	204.2	204.2	204.3	204.3	237.0	90.5	90.5	177.3
Pesticides	248.8	248.8	248.8	248.8	124.4			124.4
Drying	212.6	438.5	421.7	526.0	0			175.3
Irrigation	906.4	906.4	906.4	906.4	498.5			468.3
Nitrogen	0.0	1041.7	0.0	1041.7	0	0	520.8	520.8
Manure	0.0		0.0		0	0		0.0
Phosphorus	0.0		0.0		0	0	11.1	3.7
Potassium	0.0		0.0		0	0		0.0
Total Energy Input	1916.1	3183.7	2125.3	3271.3	1122.9	231.0	762.9	1719.0
Yield bu/a	73.4	151.4	145.6	181.6	47.0	30.4	43.4	
Energy Yield	6499.3	13405.9	12892.3	16080.0	5154.9	2730.3	3897.8	8377.6
Energy Ratio	3.4	4.2	6.1	4.9	4.5	11.8	5.1	4.9